

Weed mapping in the Blue Mountains – the BlueSpace experience

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Summary The need for accurate mapping of weed incursions into Blue Mountains bushland from the urbanised ridgeline has long been acknowledged. Attempts were made to adopt existing mapping methodologies to the needs of the Blue Mountains; nothing being found suitable this project was initiated. The BlueSpace project has defined a methodology for the accurate collection and use of detailed spatial data (in this case weeds), the following paper details that work and outlines some of the uses being made of the data in the Blue Mountains. This project mapped 11,673 ha of public land throughout the Blue Mountains recording exotic species on 1320 ha. A total of 594 exotic species were identified growing in Blue Mountains bushland during this initial weeds ‘census’.

Keywords BlueSpace, weed incursions, weed mapping, mapping methodology.

INTRODUCTION

Uniquely, the City of the Blue Mountains is surrounded by a World Heritage listed natural environment (Blue Mountains National Park). The City is also located at the headwaters of 46 peri-urban sub-catchments, all of which flow into the surrounding National Park, generally through at least some of the approximately 12,000 hectares of Council and Crown bushland which buffers the National Park (in rare instances private land borders the National Park).

Unlike most of Australia’s urbanisation (and indeed the world’s) the City of Blue Mountains is located upslope and upstream of both National Park and protected water catchments, significantly impacting the surrounding natural environment.

The NSW National Parks and Wildlife Service (NPWS) drafted a regional Introduced Species Management Plan for the Blue Mountains region in the mid 1990s (NPWS 1998). This plan identified that the biggest pest management problem facing Parks in the Blue Mountains was weed invasion from urban development, agreeing with perceptions developed within both Blue Mountains Council and the community.

This plan was tabled at the local Regional Weeds Committee for consideration and action. From this committee a strategy was devised to collect data on

the full extent of weed distribution across the Blue Mountains region.

Prior to commencing the project no objective, quantitative data existed on weed distribution and composition. There was however, limited bushland condition mapping which had been undertaken in an ad-hoc, project-based manner.

In order that additional resources could be allocated, that available resources could be used most efficiently, that those resources could be bolstered, and that the greatest impact be made on the most damaging weeds, data was needed to allow these decisions to be made.

Available mapping systems and methods were assessed against the specific needs of the Blue Mountains and found to be inadequate because they did not produce adequately detailed data sets and failed to deal with large areas of natural land.

A new approach was required, one which could deal with a broad range of exotic species in 12,000 hectares of native vegetation, steep topography, and a lack of cadastral navigation points yet still produce an accurate data-set.

That new approach is now known as ‘BlueSpace’ mapping, and it is applicable to a range of natural area management spatial mapping uses.

While this project focused on weed mapping, data collected through this project can be queried regarding degrading impact or human impact creating the weed presence, as well as weed presence or absence and weed species density. Redesigning the data collection process would allow this process to map any range of natural resource management issues.

PROJECT ESTABLISHMENT

The Blue Mountains Regional Weeds Committee saw the need in 1996 to quantify the extent of weed infestation from the City’s urbanised ridgeline, through Council and Crown bushland buffers into the surrounding National Park. Funding was jointly provided by the NSW National Parks and Wildlife Service (NPWS) and the Hawkesbury Nepean Catchment Management Trust (HNCMT) to identify or develop the most appropriate mapping system for the Blue Mountains.

As the greatest level of known infestation occurred on Blue Mountains City Council (BMCC) land it was seen to be appropriate that Council took the lead in managing this project.

Existing mapping methodologies available in Australia and overseas were examined and, while appropriate for their targeted environments, such as remnant bushland in urban environments, broad scale agricultural lands or small patches of bushland, they were found to not adequately meet the needs of the Blue Mountains environment.

Alternatively, systems which could potentially have been applied to the City were found to provide a limited data-set, i.e. overall weed density for a polygon with no species listings, or weed densities per each of three layers within a polygon with no species listings, providing only generic information on weed population densities.

In examining these systems the needs of the Blue Mountains became clearer. What was needed included:

- An ability to map large, remote, isolated areas of bushland.
- Detailed data collection, allowing detailed data querying:
 - weed species location
 - species density
 - species composition
 - degrading impacts.
- Accurate data collection to ~1 m accuracy.
- Geographic information system (GIS) compatibility.

‘BLUESPACE’ METHODOLOGY DEVELOPMENT AND IMPLEMENTATION

The system that has been developed involves the following steps:

1. Base data developed In the case of broad scale bushland mapping this has been infra-red (IR) aerial photography. In urban environments this can readily be an existing cadastral data set and in broad agricultural areas IR or true colour photography may be appropriate. The area to be mapped must be identified and an appropriate level of base data identified.

In the Blue Mountains IR photography was required due to the broad scale of areas to be mapped, the uniformity of much of the bushland and a requirement to accurately navigate in areas where GPS is not an available option (due to canopy cover).

The raw photography required manipulation (Georectification) to correct spatial errors at the edges. These errors are present in all aerial photography but were exacerbated in the Blue Mountains with our steep and variable topography.

Georectified IR photography at a small scale (flown at 1:6000, printed for field use at 1:2000) has enabled data collectors to identify their location on the ground accurately, individual trees and boulders can be readily identified, allowing easy identification of ground location and therefore accurate data recording. Layers of property boundaries and land ownership were overlaid by the GIS operator prior to printing maps for data collection. This information increased accuracy of location.

An advantage of IR photography over true colour aerial photography is the ability to differentiate canopy plant communities. In a bushland setting this assists with ground location and is a significant improvement in broad scale vegetation mapping over traditional true colour imagery (Douglas 2001). In a rural or agricultural setting this canopy community may well be at grazing height and therefore may assist with rapid identification of species such as serrated tussock (*Nassella trichotoma* (Nees) Hack. ex Arechav.), blackberry (*Rubus fruticosus* L. s.lat) and St. John's wort (*Hypericum perforatum* L.). If this remote sensing is attempted the timing of photography is critical, and care must be exercised in any georectification exercise not to lose the colour differentiation.

2. Data collection forms developed This involved the identification of required data, the development of a trial form, implementing and refining potential formats, discarding non-essential information from the system and arriving at a final format.

Initially eight layers of vegetation were reported on, however experience with this data collection method revealed that limited additional information was being generated at great cost.

Subsequent data collection has been at the three-layer level:

- Tree
- Shrub
- Understorey

In order that previously captured data not be lost the database has been developed to cope with the original eight-layer system. It is recommended that anyone pursuing this mapping methodology adhere to the three-layer data collection protocol.

3. Data base development Large amounts of data are generated using this system which requires management, also with a well written data base system the data can be queried very extensively. The system used by ‘BlueSpace’ was commissioned from a local programmer, and was written using the Microsoft Access database program.

4. Preparation of data collection information This included the identification of areas of public land within a target catchment and the production of A4 prints of the IR photography data at 1:2000 scale covering areas of public land in the target catchment, along with relevant cadastral information for use in the field by data collectors.

5. Data collection With IR photography of the target catchment trained data collectors (local bush regenerators in teams of two) identified areas of weed infestation, identified the weeds present and their density, and defined polygons (discrete areas containing a weed density or species composition differing from neighbouring areas) on the IR photograph locating the boundaries of these discrete infestations.

With every change in species composition or density a new polygon is identified and a new data form is completed.

For each polygon, the following information is collected:

- The weed species identified at the site, and in which vegetation layer they occur.
- The density of each species (1–5 scale) – indicating the degree of infestation of weed species.
- The per cent weed cover in different vegetation layers – this indicates the health of the bushland and its ability to recover.
- The impacts fostering weed growth.

Data entry into the system involves a transfer of data from the data collection form to the digital data base for each discrete polygon with digitising of polygons into a distinct layer within the GIS managed by BMCC. The database is linked to the GIS, allowing information to be extracted regarding specific weed infestations, or for specific sites within the Blue Mountains.

6. Map production The information within the database can be queried to produce a report, which can either be linked to the GIS to produce thematic maps illustrating the results of specific queries, or used in the production of reports and funding applications.

Some uses the data has been put to include:

- Maps shown on the GIS which list weeds present and density in any given polygon.
- Maps of specific weeds showing their presence and density.
- Maps showing derived Bushland Condition mapping.
- Tables defining the area and density of infestation of specific weeds, used in reports and grant applications.

The weed mapping dataset can also be queried in conjunction with accurate bushland vegetation mapping

to answer questions such as:

- What weeds are found in hanging swamps?
- Which rainforest environments have noxious weeds present?

Overlaying data produced by BlueSpace onto accurate vegetation mapping layers rapidly answers these questions. Both sets of data must be compatible in scale and base data for this to be successful. In the Blue Mountains infra-red photography was the base data-set for both projects, and their scale is flexible within the GIS ensuring consistent data and accurate outputs.

PROJECT IMPLEMENTATION AND OUTCOMES

Following the development and trialing of this methodology, funding was obtained from the BMURCP to map the whole of the Blue Mountains City Council area.

Aerial photography, flown at 1:6000 cost approximately \$70,000 and was funded by the URCP. This data was georectified by BMCC specialist staff and has been inherited by BMCC. For project implementation, the URCP allocated \$150,000 for a Project Officer's position and to employ three teams of contract data collectors over 12 months. Approximately 90% of the bushland under Crown and Council control in the Blue Mountains City's urbanised catchments has been mapped.

Data collection was the bottleneck in the system with data input outpacing data collection by a 4:1 ratio. Querying the data once in the system is rapid and effective. As at 1 August 2001 11,673 hectares of crown and council public land within the Blue Mountains LGA had been mapped (at a total cost of almost \$20 ha⁻¹ or \$12.85 ha⁻¹ for data collection only), identifying 1320 hectares of land infested with weeds at any density. The system has identified 594 weed species in the City, a number of which were previously unknown as bushland invaders. The actual number of exotic species in the City is likely to be higher than this, with a small number of species identified only to genus. This flaw is being corrected with assistance from the Weeds CRC.

The collated data is currently being used by Blue Mountains Bushcare groups, BMCC environmental management staff for planning and prioritising bushland restoration and rehabilitation works, directing staff and contractors, and preparing funding submissions. The data is also being used to prepare and to evaluate bush regeneration and other weed control contracts. The three Sydney Catchment Authority (SCA) catchments within the City have been mapped and the data is being used by SCA staff in their management decision-making process.

The Blue Mountains Noxious and Environmental Weeds Group, a multi-agency working group comprising various governmental agencies and members of the community, are also using the system to effectively prioritise noxious and environmental weed control. The system enables sound decision making at all levels of weed control and allows scarce resources to be applied to the greatest effect.

Council Environmental Management staff are using the data in contract preparation and contract monitoring and performance assessment.

A simple example of the use of this data is the recently contracted *Salix* removal project. This project is part of a larger program aiming to eradicate *Salix cinerea* L., *S. nigra* Marshall and *S. purpurea* L. from the Blue Mountains. The initial project is aiming to remove all *S. cinerea*, *S. nigra* and *S. purpurea* which can be removed from public land in one growing season without either i) encouraging weed succession, or ii) creating erosion hazards.

Accompanying the scope of works was a map set comprising 60 A3 1:2500 cadastral maps of the City identifying all *Salix* infestations mapped under

BlueSpace. The maps show the polygon, report its number and the density of infestation, and through colour coding identified the *Salix* species composition within the polygon. An accompanying nine page data table was also sent to the contractors to provide greater clarity. The following graphs display the summary data obtained via BlueSpace.

A total of 305 sites have been identified as containing *Salix* infestations. Of these almost 50% (150 records) contain *S. cinerea*. However, *S. cinerea* is only present in 18.4 ha (or 24.86%) of the 74 ha containing *Salix* generally (Figures 1 and 2).

This level of data can be readily generated for all weeds identified through the mapping, it can be generated for groups of weeds (i.e. all Noxious, all W2 etc.), or data can be generated which details the species present in more detailed areas (such as soon to be released contract areas).

CONCLUSION

This project has developed and tested a new method for quantifying land management issues in a spatial context. Specifically the system has focused on

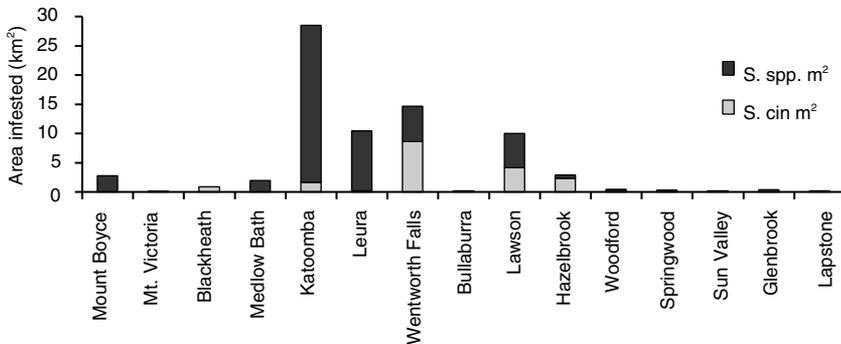


Figure 1. Area of *Salix* infestation (m²) recorded per village.

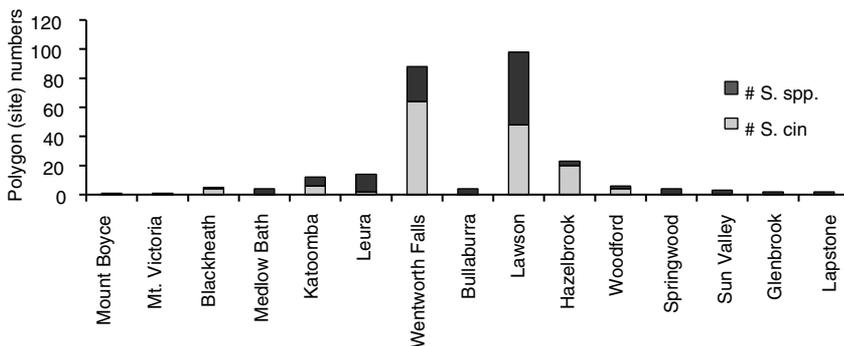


Figure 2. Number of *Salix* infestations recorded across the Blue Mountains, per village.

mapping the weeds of the Blue Mountains LGA. The system could equally be applied to the mapping of saline affected pasture lands, acid sulphate affected coastal and flood plain lands, or any other environmental management issue where greater detail is required than is currently being captured.

In the above example saline affected lands would be identified spatially, polygons developed based on the degree of surface crusting and changes in the health and composition of pasture species surrounding the surface crusts. Extrapolations could be made from this ground mapping to predict future saline outbreak sites.

The project has supplied a snapshot of the weed problem on public land in the Blue Mountains during 2000–2001 (12 months of data collection) allowing accurate decision making to be made by Government agencies and the community as to priority weed management. This baseline data also allows successes and failures of weed management activities to be accurately identified and quantified, following subsequent data collection processes. This in turn will further enhance program efficiencies.

Data within the system can be updated at any time and as with any data management system relies on up to date data to ensure its viability and use as a management tool. Changes in the temporal data set supersede the previous data, which is retained for comparison purposes. The Blue Mountains Council has given an in principle commitment to ongoing data collection as it is realised the benefits of such an environmental management system. Options for the continued enhancement of the dataset include:

- Updating data post-weed control works in specific sites.
- Re-mapping specific sub-catchments on a revolving basis as resources allow.
- Re-mapping on a five-year cycle as per BMCC's five local planning areas.
- Re-mapping areas highlighted through this baseline data collection process as weed infested on a regular (2–3 year cycle).

Any of the above processes will produce the desired outcome.

Private lands within BMCC have been monitored by Noxious Weeds officers inspecting properties, this data is now being captured via GPS linked to laptops, allowing this data to be linked and displayed via BlueSpace.

Early reports from field staff utilising the system have been glowing:

'It took us three hours to deal with all our target weeds at Medlow Bath this year, its always taken us three days in the past, this time we went straight to the sites and the job was so easy.'

Within the Blue Mountains significant weed problems exist with a substantial treatment time frame, specifically gorse (*Ulex europaeus* L.) and Scotch broom (*Cytisus scoparius* L.) which both require long term management. In the case of gorse, 90% of known infestations have been controlled through a concerted inter-agency response to an emerging issue in the 1990s. However, given the 80 year seed viability of this species failure to maintain management of these treated sites into the long term will allow a reinfestation of the Mountains, with BlueSpace we have accurately identified these sites and gorse control will continue even with the several complete staff turnovers which can be expected.

New weed incursions can be mapped and reacted to quickly using ongoing mapping protocols, and degrading impacts that are influencing the presence/severity of weed infestations can also be prioritised.

Utilising the excellent GIS data set possessed by BMCC allows for comparison of weed infestation against endangered species/communities, allowing a prioritisation of works on biodiversity grounds, it allows for comparison against past infrastructure works or against existing sewer or stormwater drains, areas of road work, new subdivisions, etc. Linking the BlueSpace system with an effective existing GIS dataset greatly enhances the power of both systems to enhance management decision-making regarding weed control (or other natural resource management issues for which the system can be used).

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