Extending the South West Regional Ecological Linkages in the South West Catchments Council Region: Developing the Draft Linkages.

Shaun Molloy and Jodie Deeley

June 2013

Citation

Molloy, S.W. and Deeley, J (2013). Extending the South West Regional Ecological Linkages across the South West Catchments Council Region: Developing the Draft Linkages. Bunbury: South West Catchments Council.

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Caveats

The information contained in this publication is intended for general use, to assist in the development and implementation of a regional ecological linkages project for the South West Catchments Council region. It includes general statements based on scientific research. Readers are advised and need to be aware that this information may be incomplete or unsuitable for use in specific situations. Before taking any action or decision based on the information in this publication, readers should seek expert professional, scientific and technical advice.

Synopsis

In response to ecological issues arising from landscape fragmentation and the predicted impacts of climate change across its region, the South West Catchments Council (SWCC) has recognised the need to identify a series of ecological linkages at a regional scale. As a preliminary exercise, SWCC has chosen to adopt the products and methodologies of the South West Regional Ecological Linkages Project (SWREL) and expand this work across the entire region, i.e. into the eastern Jarrah Forest, Avon Wheatbelt, and Mallee Interim Biogeographic Regionalisation of Australia areas of its region and into the Serpentine-Jarrahdale Shire.

These ecological linkages are designed to function at the regional scale and to meet regional planning objectives. They have not been designed to supplant local scale connectivity planning. Rather, it is the purpose of this project to help recognise the contributions made through localised conservation planning initiatives towards conservation outcomes throughout the whole SWCC region.

The SWREL linkages, a series of axis lines applied through a proximity analysis methodology and developed through a community consultation process supported by spatial modeling applications and ecological principles, are supported by the Western Australian Environmental Protection Authority and the Western Australian Planning Commission.

In comparison with the original SWREL linkages, the extensions cover a highly fragmented landscape with much lower remnant vegetation cover. Consequently, although the guiding principles and methodologies of this initiative have been adopted, vegetation extent by sub-catchment and fragmentation analysis has also been incorporated into the planning process.

The extended ecological linkages have been developed as a preliminary planning exercise through a desktop GIS process without the benefit of ground truthing or community consultation and are static in nature, in that potential future scenarios resulting from changes in variables such as climate, land use or hydrology have not been considered. Therefore, it is recommended that extensive ground truthing and community consultation be undertaken before initiating on ground activities.

Contents

Background

The South West Catchments Council (SWCC) has undertaken a planning exercise to identify means by which the products of the South West Regional Ecological Linkages (SWREL) project can be rolled out across the full extent of its mandated region. This will extend the SWREL linkages into the eastern Jarrah Forest, Avon Wheatbelt, and Mallee Interim Biogeographic Regionalisation of Australia areas of its region and into the Serpentine-Jarrahdale Shire. This is to be done in consideration of the following points:

- Existing SWREL linkages are, generally, still to be considered adequate for applicable landscapes.

- This is a preliminary exercise which will not, at this level, include fieldwork, community engagement, climate change modelling, or viability analyses.

- The ecological linkages in this project are designed to function at the regional scale and to meet regional planning objectives. They have not been designed to supplant local scale connectivity planning.

- This exercise is to be completed by 30/06/2013.

The South West Regional Ecological Linkages (SWREL) (Molloy *et al.* 2009) are a series of regional scale ecological linkages developed through a community consultation process supported by spatial modeling and the application of ecological principles. In this methodology ecological linkage values are applied to patch matrices by applying a proximity analysis methodology to a set of linkage axis lines. The SWREL project is supported by the Western Australian Environmental Protection Authority and the Western Australian Planning Commission (Environmental Protection Authority, 2009).

The existing SWREL linkages have been designed to be extended across the comparatively high rainfall areas of the southern Swan Coastal Plain and Jarrah Forest IBRA regions (Thackway & Cresswell 1995) where annual average rainfall is above 650mm and remnant vegetation coverage is generally >20%. East of these areas, remnant vegetation cover can drop to well below 10%. In situations such as these, direct, or corridor, connectivity at the landscape level becomes largely impractical (Beger *et al.* 2010: Beier *et al.* 2008; Rouget *et al.* 2006). In such landscapes the emphasis of conservation ecology becomes one of identification of assets, mitigation of threats and the building of resilience at a landscape level (Lindenmayer *et al.* 2008). The recognition of ecological linkages becomes reliant on prioritising landscapes of high conservation value (as previously identified as the SWCC NRM Strategy Biolandscapes) and recognising landscapes with an inherently high linkage

value, i.e. landscapes with a comparatively high proportion of remnant vegetation and whose patch matrix will facilitate ecological connectivity at landscape and regional scales (Collinge, 2009; Lindenmayer & Fischer, 2006; McGarigal *et al*., 2009).

Methodology

The following steps were taken in the generation of the ecological linkage axis lines:

1. Linkage axis lines as defined and identified through the SWREL project (Molloy *et al*., 2009) were adapted as a starting point from which additional linkage lines were added to encompass the SWCC mandated region. Minor amendments were made to the existing SWREL lines through the Jarrah Forest IBRA regions to facilitate connectivity at the regional scale

2. In areas beyond the boundaries of the SWREL project area, appropriate major watercourses for the Eastern Jarrah Forest, Avon Wheatbelt and Mallee Interim Biogeographic Regions of Australia (IBRA) regions (within the extent of the SWCC mandated region) and the Serpentine-Jarrahdale Shire were selected and added to the SWREL axis lines.

3. Within the areas covered by the Eastern Jarrah Forest, Avon Wheatbelt and Mallee IBRA regions and the Serpentine-Jarrahdale Shire two data sets were developed to inform the planning process. These were percentage of remnant vegetation per sub-catchment and average fragmentation statistic (McGarigal *et al*., 2009) per sub catchment.

4. The SWCC NRM Strategy Biolandscapes (Ecosystem Solutions Pty Ltd, 2009) were identified as priorities.

5. Draft ecological linkage axis lines were identified using these data sets.

6. The draft ecological linkages were then evaluated using a Proximity Analysis to assess their effectiveness.

7. Ecological linkages were reviewed, edited and finalised.

As per the SWREL methodology, the following guiding principles were used to create the ecological linkage axis lines. However it is recognised that across much of the project area there may be insufficient patches with these properties available and in such cases patches not meeting these criteria were used.

- Where available, patches should be at least 10 ha in size and of good or better condition;

- Continuous stands of native vegetation with a preferred width of >500 m should be chosen where available;

- Thin remnants (<100m wide) should be avoided where it is practical to do so;

- Heterogeneity in patch structure should be sought;

- The widest possible diversity of habitat types should be sought within a linkage with similar habitats (preferably) less than 1000m apart;

- Open canopies over a highly disturbed understorey may be of little value except for highly mobile species;

- Where continuous stands of native vegetation are not available, linkages made up of patches which form stepping stones between larger intact patches should be selected;

- The target maximum between patches is <1000 m (although closer proximities between patches are preferred distances >1000m will be considered in highly fragmented landscapes);

- The greater a patch's area the greater its capacity to maintain a larger and more viable suite of species;

- The number of linkages connecting to any given patch should be maximised as this improves overall connectivity across the landscape and long-term viability of individual patches;

- Patches should be chosen whose shapes minimise edge effects;

- The potential effects of stochastic and deterministic abiotic processes (such as the impacts of wind and water movements and their potential for secondary effects such as dryland salinity, erosion and acidification) within a landscape should be considered.

As per the SWREL methodology, the following areas have been given high priority for inclusion in the linkage:

1. Patches forming the most direct links with regionally significant patches or other identified Ecological Linkage;

2. Ecological Linkages should be selected whose directions facilitate normal migration, and aid in the adaptation of species and assemblages to climate change;

3. Riparian vegetation along waterways including an appropriate buffer of non-riparian vegetation;

4. Patches that enhance the viability of significant biodiversity conservation assets and initiatives through conserving both species and structural heterogeneity and therefore habitat values;

5. Patches at high points in the landscape that are in the line of sight of other patches. Line of sight is important for species dispersal and home range utilisation.

In addition, the following areas have been given high priority for inclusion in the linkage:

6. Sub-catchments with a high percentage of remnant vegetation;

7. Sub-catchments with a high average fragstat statistic;

8. SWCC NRM Strategy Biolandscapes (Ecosystem Solutions Pty Ltd, 2009).

Note: *These principles are aspirational in nature and, given the extent of fragmentation across much of the SWCC region, may not be practical in all landscapes. For example; some landscapes may not have sufficient patches with an area of >10ha or a width of >100m available to form a linkage or suitable patches may be > 1000m apart.*

Fragstat analysis

Fragmentation statistics, or proximity indices, were calculated using the V-Late 2.0 beta extension for ArcGIS 10.1®. Statistics are computed as the sum, over all patches of the corresponding patch type whose edges are within the search radius of the focal patch, of each patch size divided by the square of its distance from the focal patch. Proximity is then averaged across all patches with a buffered distance for each patch, thereby quantifying the spatial context of a patch in relation to its neighbors of the same class; specifically, the index distinguishes sparse distributions of small patches from configurations where the class forms a complex cluster of larger patches. Thus, the proximity index measures both the degree of patch isolation and the degree of fragmentation of the corresponding patch type within the specified neighborhood for each patch (McGarigal *et al*., 2009).

In this application, sub-catchments were categorised by IBRA region, reflecting the different levels of fragmentation within each region, with overlaps to compensate for variation between relevant boundaries. Fragmentation statistics were calculated for all patches of remnant vegetation within (both totally and partially) each sub-catchment and an average

value calculated. Results were presented as quintiles defined by natural, Jenk's breaks for each IBRA region.

Remnant vegetation extent

As with the Fragstat analysis, sub-catchments were categorised by IBRA region, reflecting the different levels of fragmentation within each region, with overlaps to compensate for variation between relevant boundaries. Percentage of remnant vegetation for each sub-catchment was calculated with ArcGIS 10.1®. Results were presented as quintiles defined by natural, Jenk's, breaks for each IBRA region.

Proximity analysis

The proximity analysis methodology relies on assigning a connectivity value to a patch relative to a linkage axis line. Values are defined as:

Table 1: Proximity analysis values described.

Value	Description
1a,	The whole of a patch whose edge touches, or comes within a distance ≤ 100m from, a linkage axis line.
1b,	The whole of a patch whose edge comes within a distance ≤ 100m from, a 1a patch.
1c,	The whole of a patch whose edge comes within a distance ≤ 100m from a 1b patch.
2a,	The whole of a patch whose edge comes within a distance ≤ 500m from a linkage axis line.
2b,	The whole of a patch whose edge comes within a distance ≤ 500m from a 2a patch.
2c,	The whole of a patch whose edge comes within a distance ≤ 500m from a 2b patch.
3a,	The whole of a patch whose edge comes within a distance ≤ 1000m from a linkage axis line.
3b,	The whole of a patch whose edge comes within a distance ≤ 1000m from a 3a patch.
3c,	The whole of a patch whose edge comes within a distance ≤ 1000m from a 3b patch.

Where a patch is assigned multiple values, the first value assigned will be kept as the nominal value. Patches not assigned a value will not be considered part of the ecological linkage.

Limitations

1) The ecological linkages produced in this project have been designed to function at the regional scale and to meet regional planning objectives. They have not been designed to supplant local scale connectivity planning. Rather, it is the purpose of this project to help recognise the contributions made through localised conservation planning initiatives towards conservation outcomes throughout the whole SWCC region.

2) As patches of remnant vegetation are removed from the matrix, or if they are diminished or enhanced in area, proximity values should be recalculated.

3) This project is static in nature; potential future impacts resulting from changes in variables such as climate, land use or hydrology have not been considered. Consequently, project products should be used in recognition of the accuracy of the data used in, and the scope of, their development.

4) As a preliminary planning exercise, the products of this project have been developed through a desktop GIS process without the benefit of ground truthing or community consultation. They have been designed for implementation at the regional scale to complement finer scale connectivity planning, not to replace it.

Bibliography

Beger, M., Linke, S., Watts, M., Game, E., Treml, E., Ball, I. & Possingham, H. P. (2010) Incorporating asymmetric connectivity into spatial decision making for conservation. *Conservation Letters* **3**(5): 359-368.

Beier, P., Majka, D. R. & Spencer, W. D. (2008) Forks in the road: choices in procedures for designing wildland linkages. *Conservation biology : the journal of the Society for Conservation Biology* **22**(4): 836-851.

Collinge, S. K. (2009) *The Ecology of Fragmented Landscapes*. Baltimore: Johns Hopkins University Press.

Dunlop, M. & Brown, P. R. (2008) Implications of climate change for Australia's national reserve system. In: *a preliminary assessment*, Canberra: Dept. of Climate Change.

Ecosystem Solutions Pty Ltd. (2009) *Biodiversity Sub-strategy for the South West Catchments Council.* Ecosystem Solutions Pty Ltd. Produced on behalf of SWCC. 113 pp.

Environmental Protection Authority. (2009). *Environmental Protection Bulletin No. 8: South West Regional Ecological Linkages*. Perth: Environmental Protection Authority.

Lindenmayer, D., Hobbs, R. J., Montague-Drake, R., Alexandra, J., Bennett, A., Burgman, M., Cale, P., Calhoun, A., Cramer, V., Cullen, P., Driscoll, D., Fahrig, L., Fischer, J., Franklin, J., Haila, Y., Hunter, M., Gibbons, P., Lake, S., Luck, G., MacGregor, C., McIntyre, S., Mac Nally, R., Manning, A., Miller, J., Mooney, H., Noss, R., Possingham, H., Saunders, D., Schmiegelow, F., Scott, M., Simberloff, D., Sisk, T., Tabor, G., Walker, B., Wiens, J., Woinarski, J. & Zavaleta, E. (2008) A checklist for ecological management of landscapes for conservation. *Ecology Letters* **11**(1): 78-91.

Lindenmayer, D. & Fischer, J. (2006). *Habitat fragmentation and landscape change : an ecological and conservation synthesis*. Collingwood, Vic.: CSIRO.

McGarigal, K., Tagil, S. & Cushman, S. A. (2009). Surface metrics: an alternative to patch metrics for the quantification of landscape structure. *Landscape Ecology, 24*(3), 433-450.

Molloy, S., Wood, J., Hall, S., Wallrodt, S. & Whisson, G. (2009) *South West Regional Ecological Linkages Technical Report*. Perth: Western Australian Local Government Association and Western Australian Department of Environment and Conservation.

Rouget, M., Cowling, R. M., Lombard, A. T., Knight, A. T. & Kerley, G. I. H. (2006) Designing large-scale conservation corridors for pattern and process. *Conservation Biology* **20**(2): 549-561.

Thackway, R. M., & Cresswell, I. D. (1995) An interim bio-geographic regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative program. In: Canberra: Australian Nature Conservation Agency.

Appendix 1: Figures

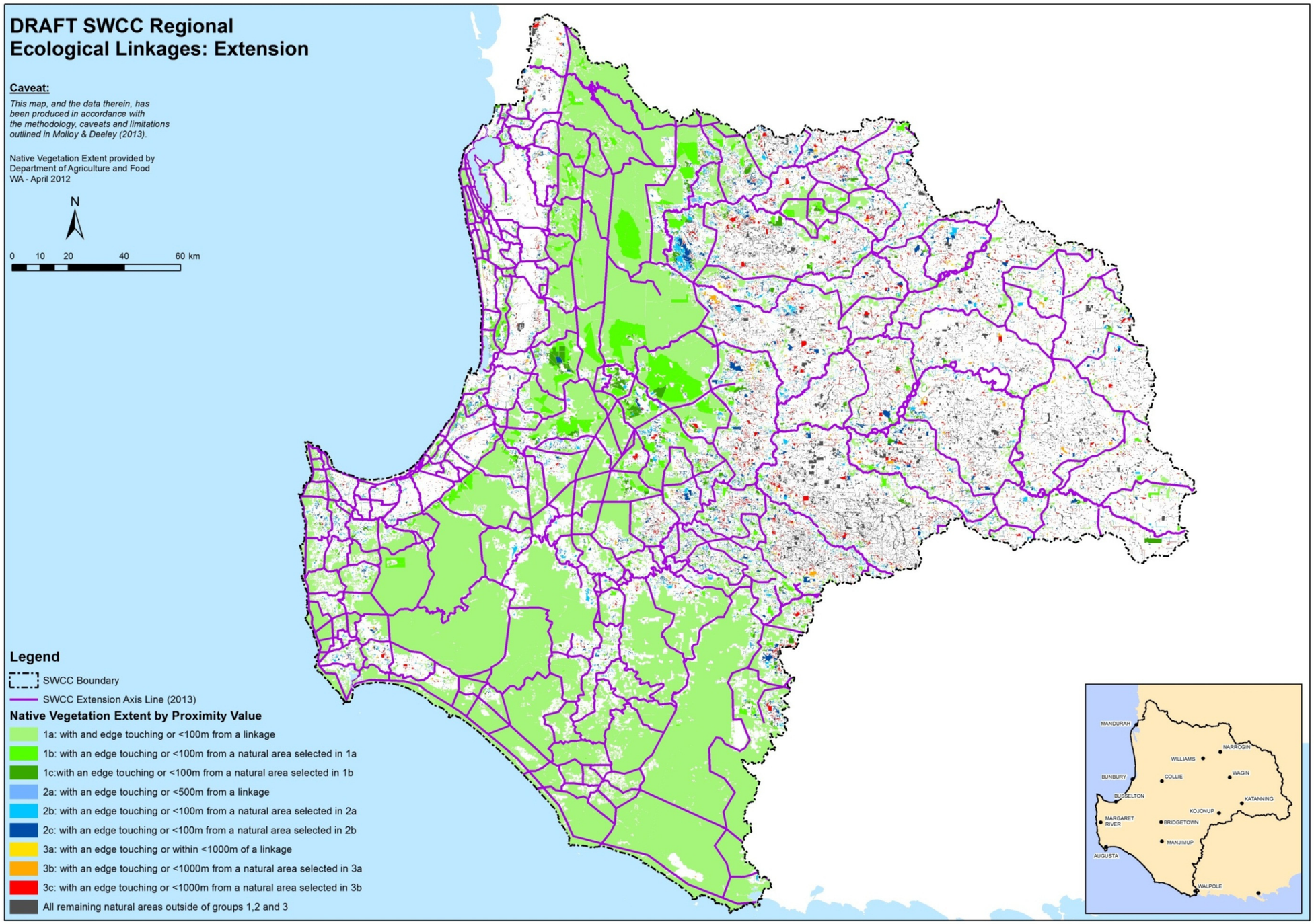

Figure 1: Native Vegetation Extent by Proximity Analysis for SWCC Region

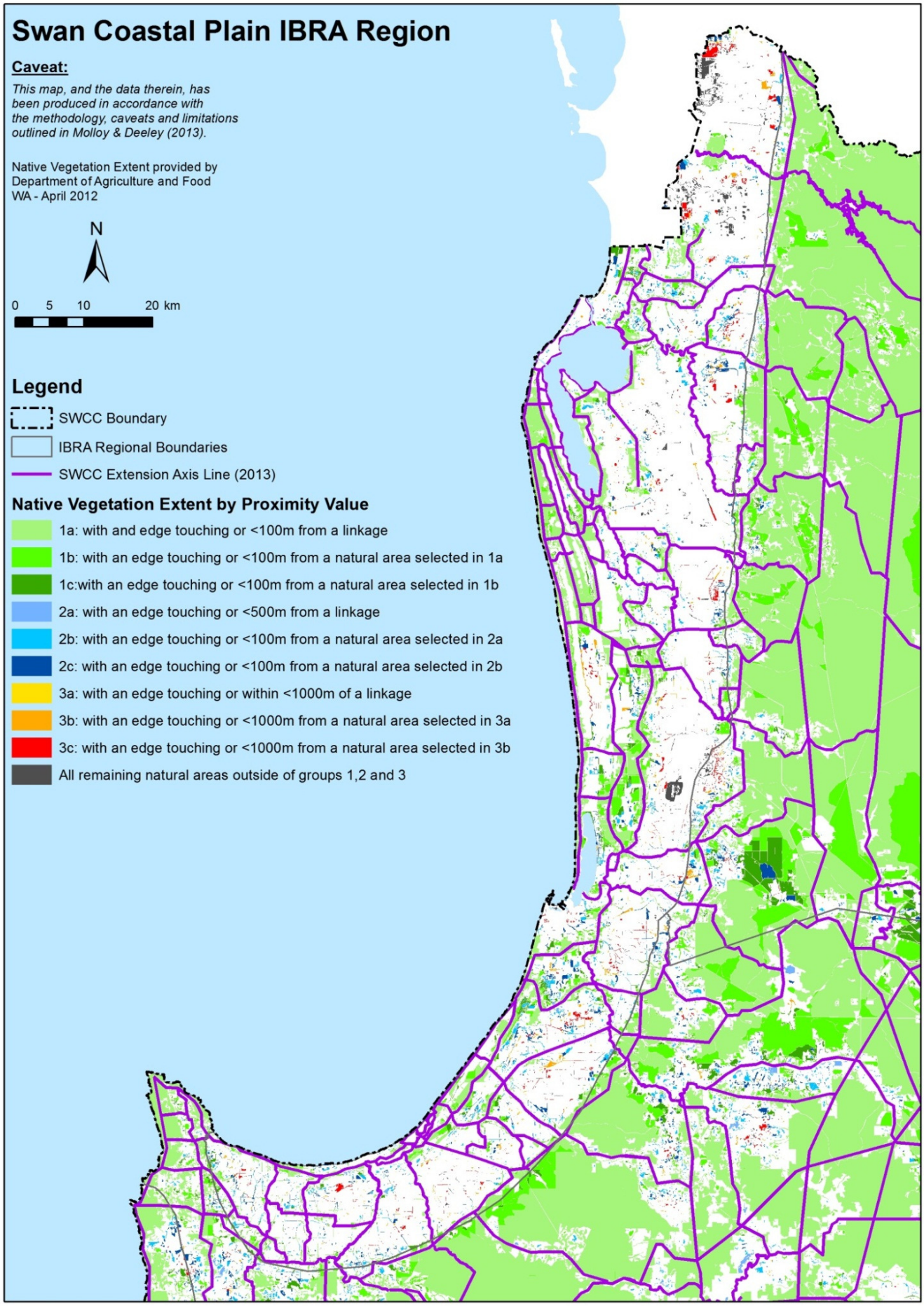

Figure 2: Native Vegetation Extent by Proximity Analysis for Swan Coastal Plain IBRA Region

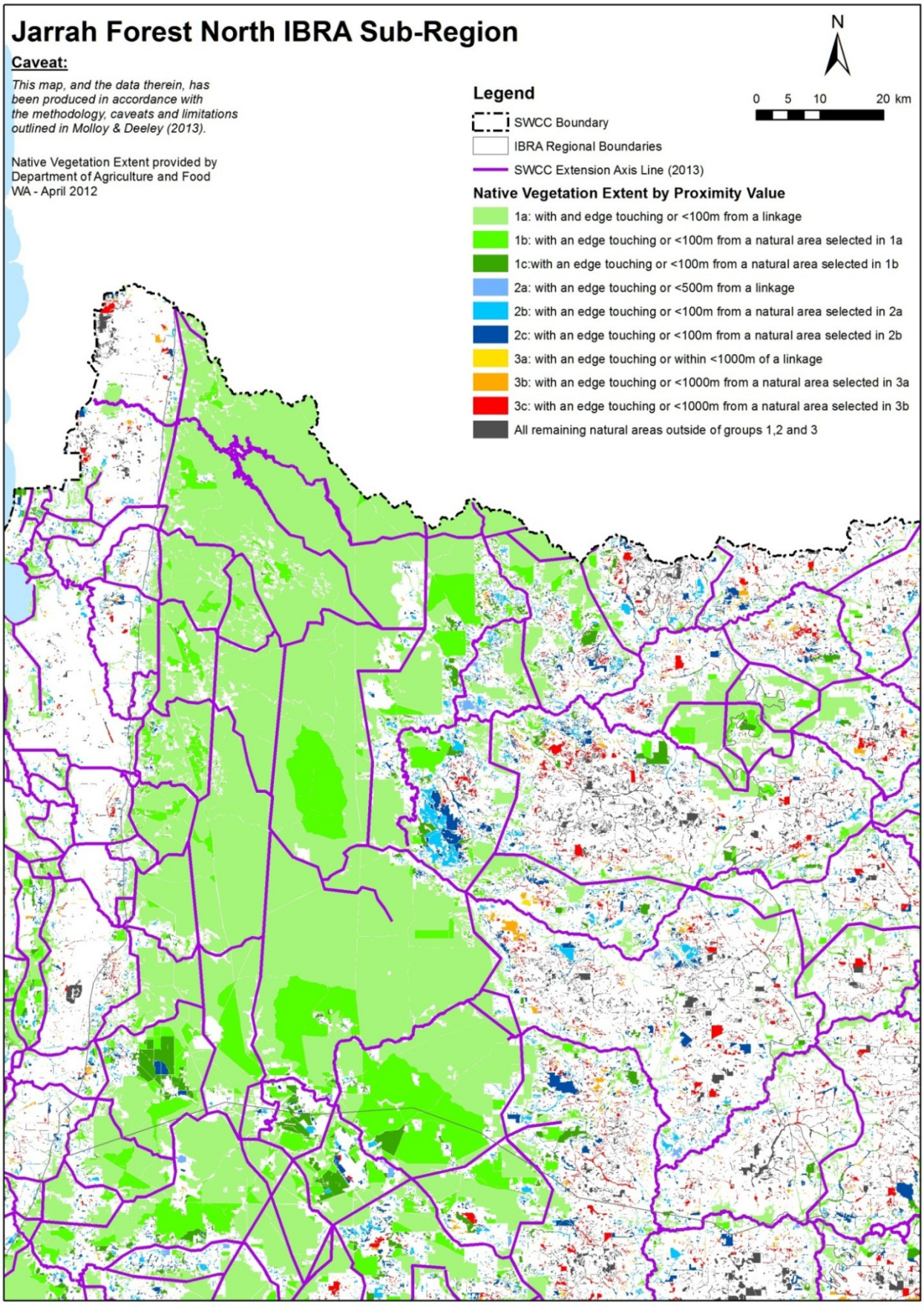

Figure 3: Native Vegetation Extent by Proximity Analysis for Jarrah Forest North IBRA Sub-Region

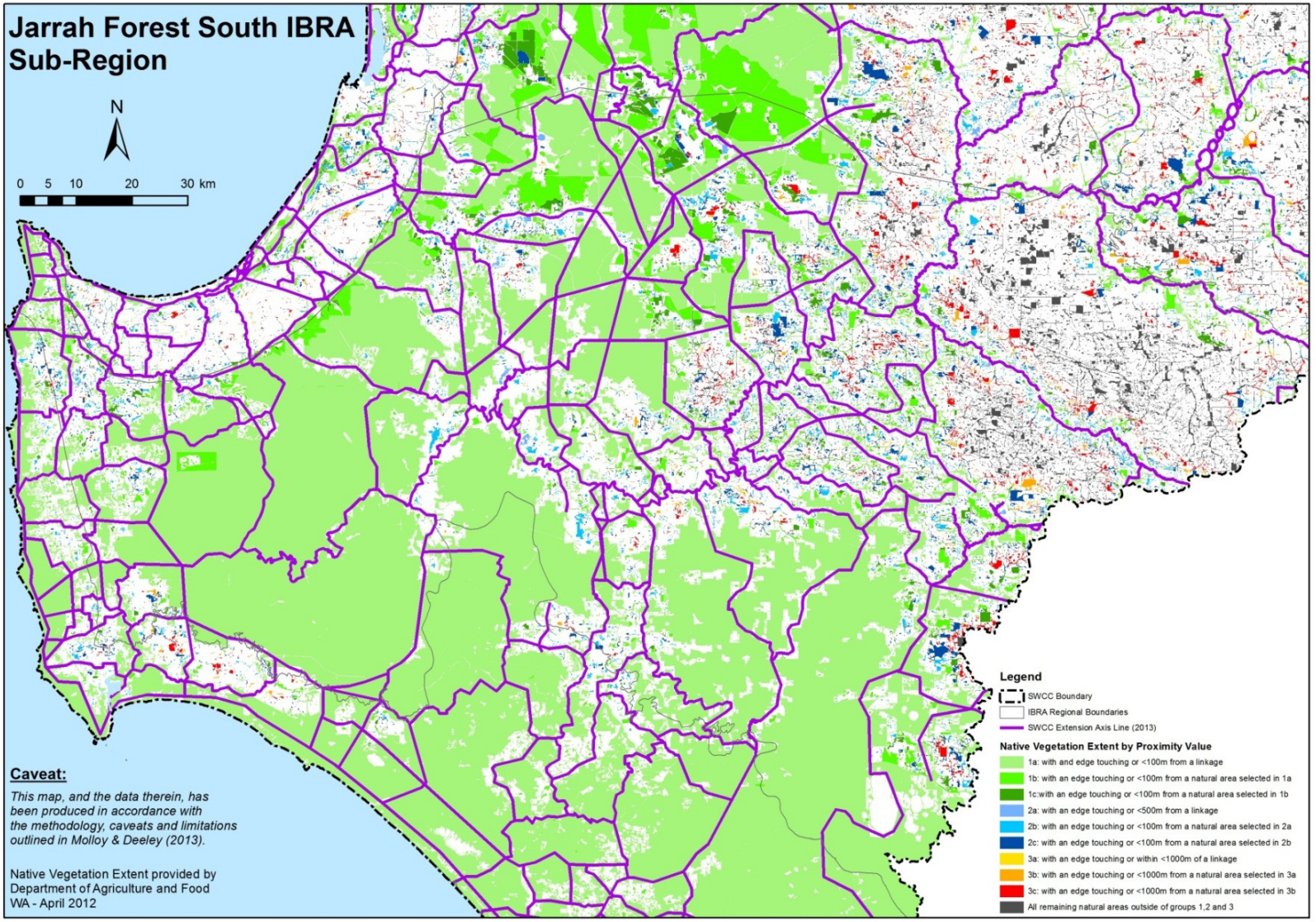

Figure 4: Native Vegetation Extent by Proximity Analysis for Jarrah Forest South IBRA Sub-Region

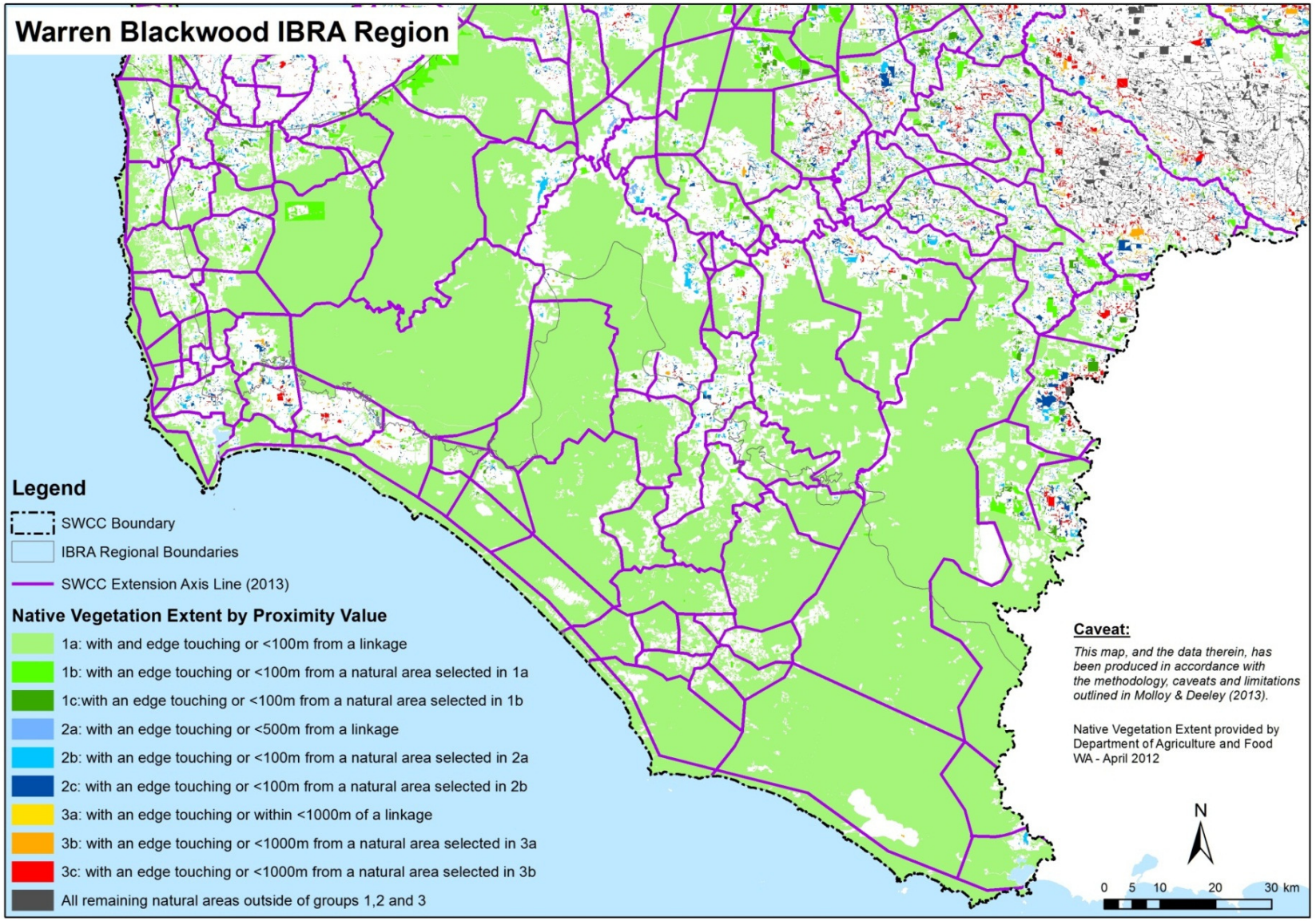

Figure 5: Native Vegetation Extent by Proximity Analysis for Warren Blackwood IBRA Region

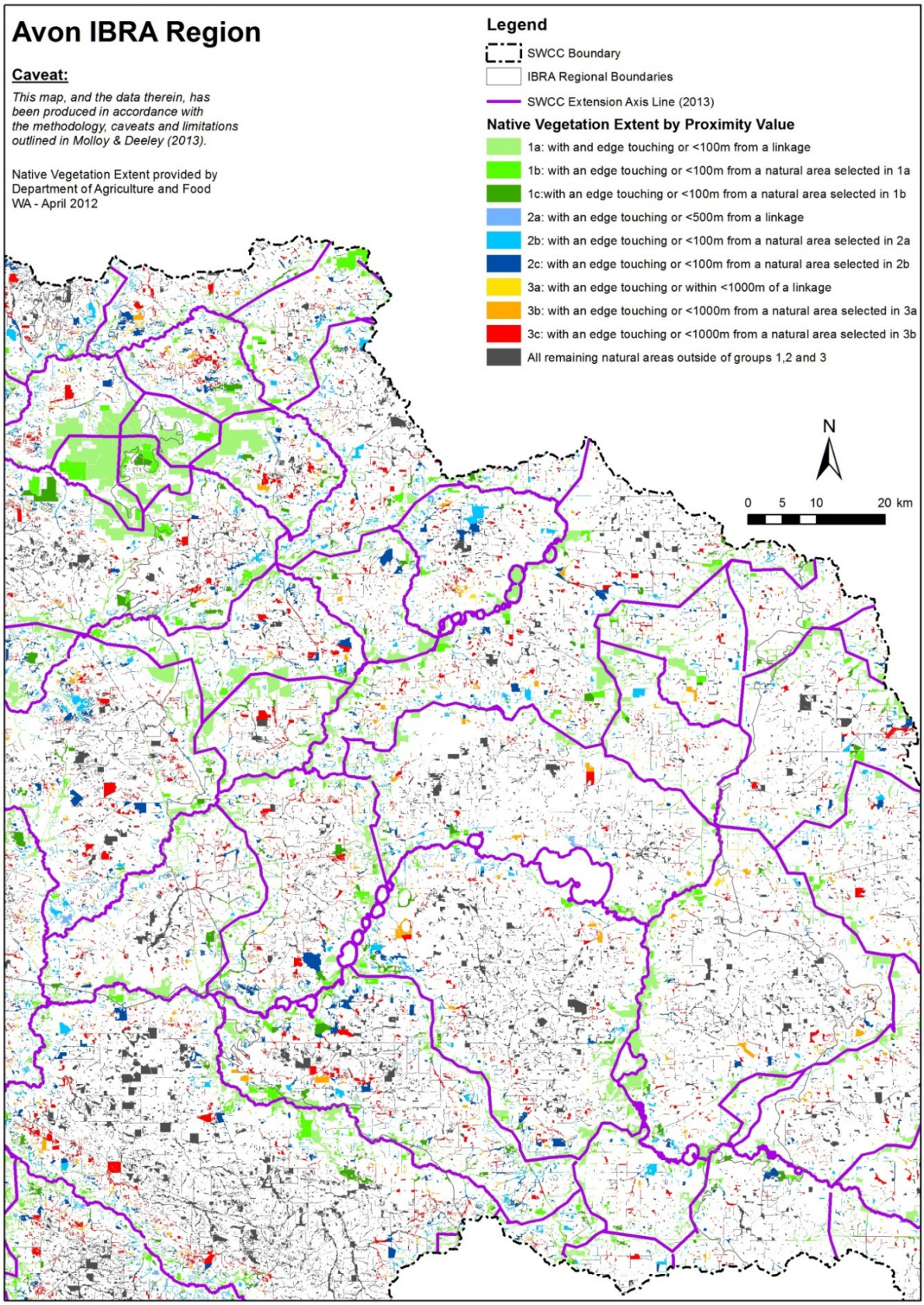

Figure 6: Native Vegetation Extent by Proximity Analysis for Avon Wheatbelt IBRA Region

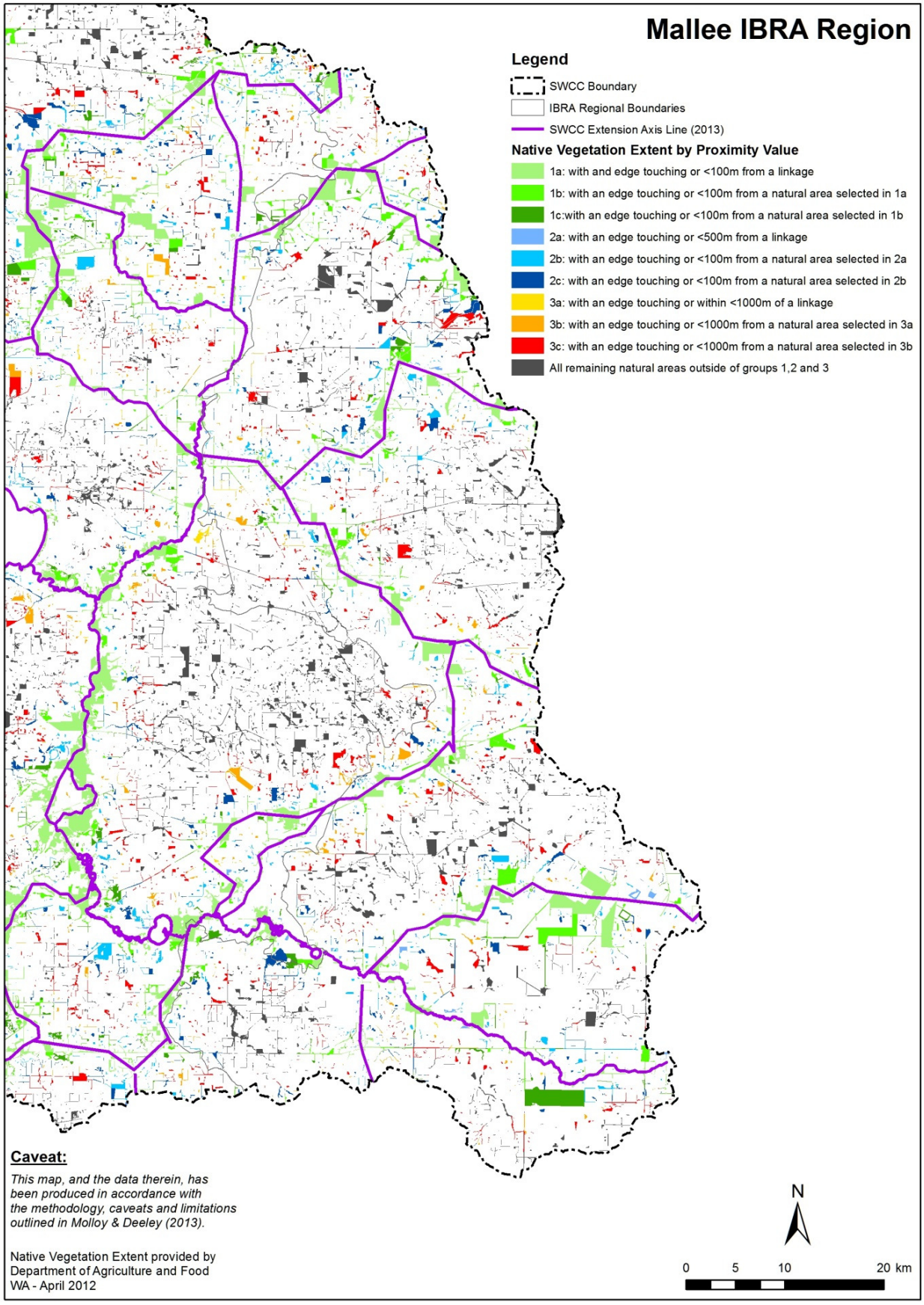

Figure 7: Native Vegetation Extent by Proximity Analysis for Mallee IBRA Region

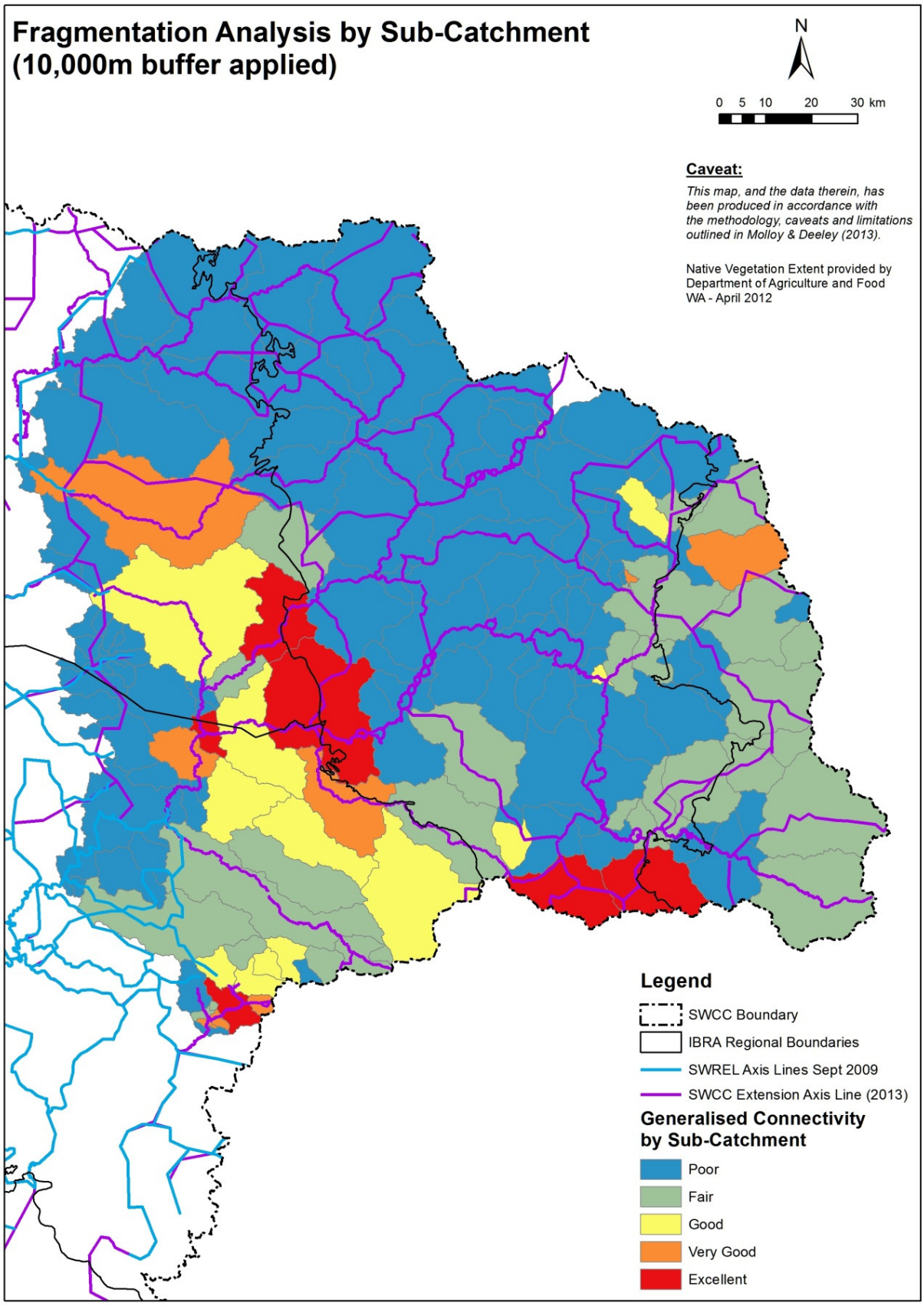

Figure 8: Fragmentation Analysis by Sub-Catchment (10,000m buffer applied)

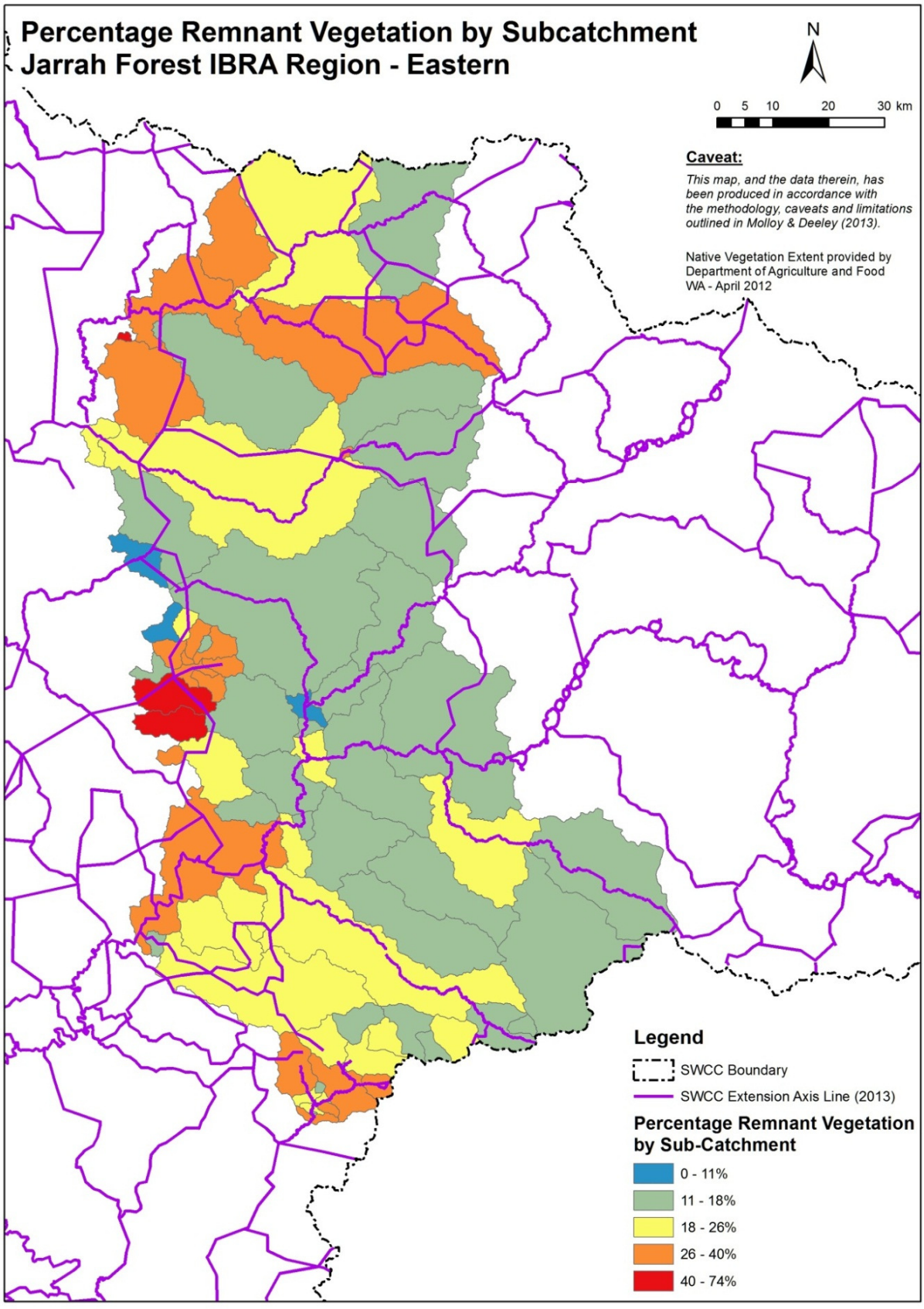

Figure 9: Percentage Vegetation Remaining per Sub-Catchment – Eastern Jarrah Forest IBRA Region

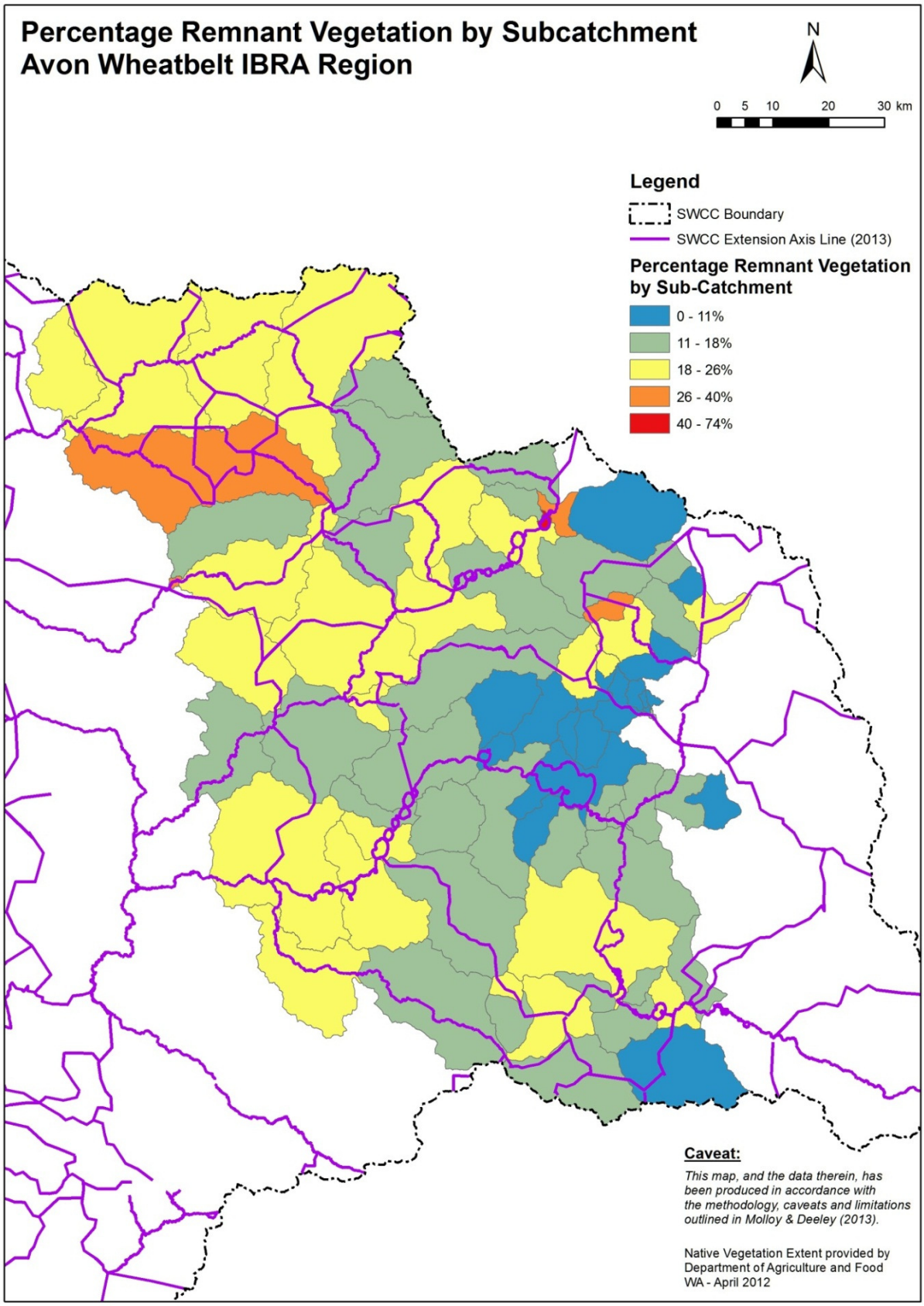

Figure 10: Percentage Vegetation Remaining per Sub-Catchment – Avon Wheatbelt IBRA Region

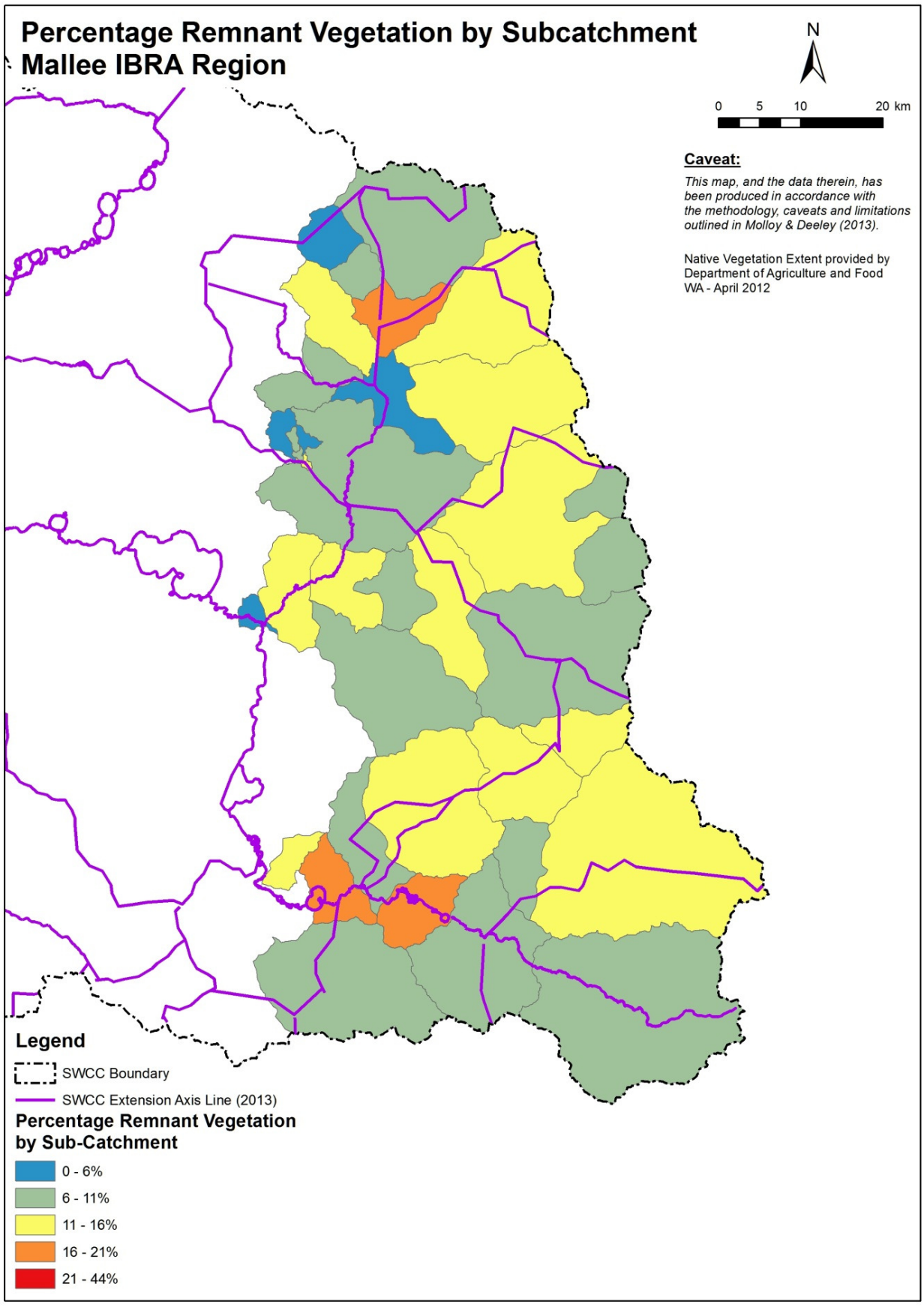

Figure 11: Percentage Vegetation Remaining per Sub-Catchment – Mallee IBRA Region

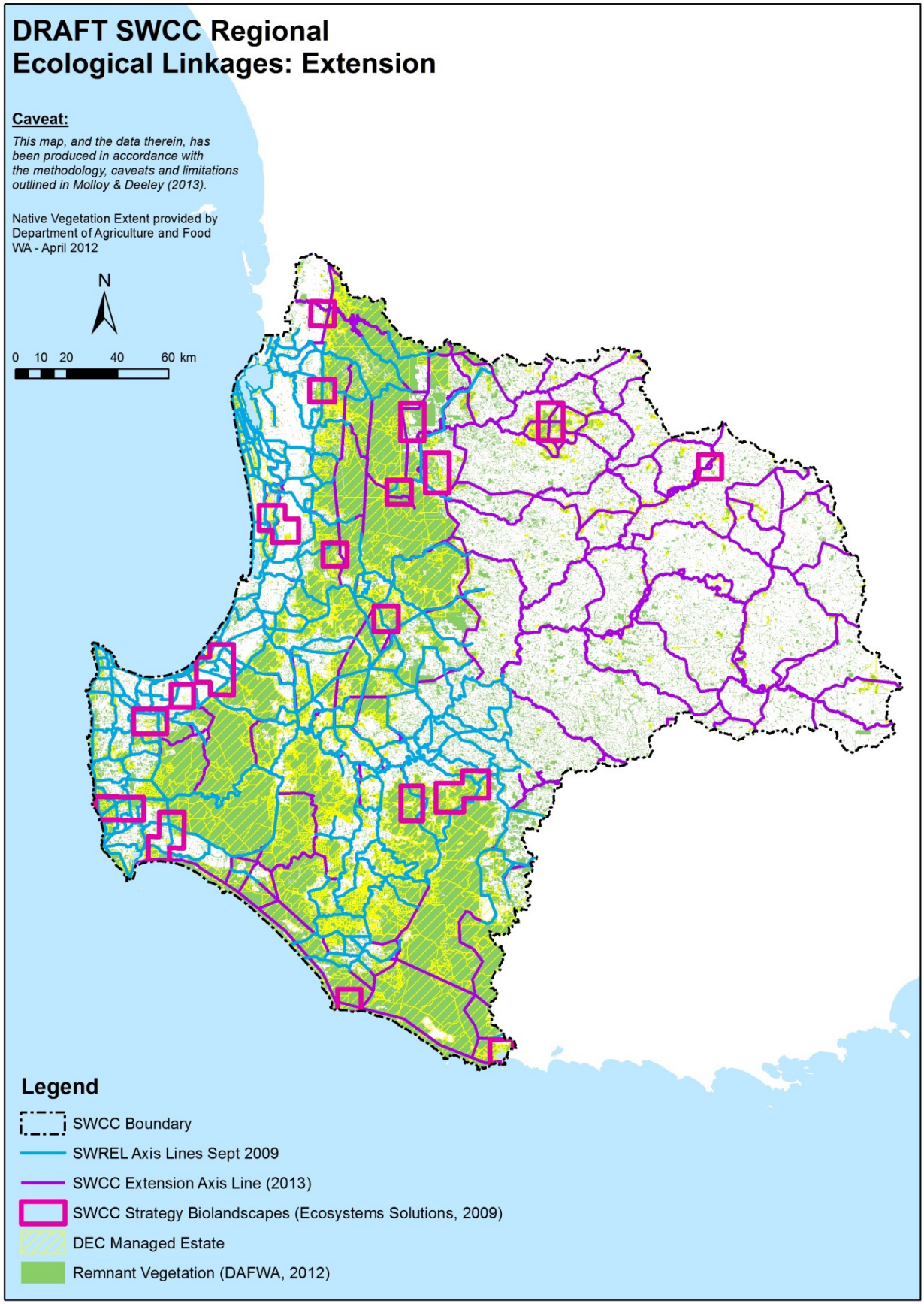

Figure 12: Draft Regional Ecological Linkages and Biolandscapes

Appendix 2: Metadata Statement

Dataset Title:	**South West Catchment Council Preliminary Ecological Linkages Axis Lines**
Custodian:	South West Catchment Council (SWCC)
Jurisdiction:	Western Australia.
Abstract:	This dataset identifies regional ecological linkage axis lines that aim to link patches of remnant vegetation judged to be of regional significance by retaining the best (condition) and/or most contiguous patches available to act as stepping stones for flora and fauna between regionally significant areas. Note: *Ecological linkages are just one measure of the biodiversity conservation value of a patch of native vegetation. Consideration of the proximity value of an ecological linkage is not intended to replace the need to consider the other biodiversity conservation values of a patch.*

GEOGRAPHIC EXTENT NAME

Geographic Extent Name Category:	not applicable
Geographic Extent	
Name Custodial Jurisdiction: Polygon:	South West, Western Australia
Geographic Bounding Box:	
North Bounding Latitude:	6448505
South Bounding Latitude:	6123355
East Bounding Longitude:	637177
West Bounding Longitude:	312904
Horizontal Coordinate:	Geographic System
Geodetic Model:	GDA 1994 MGA Zone 50
Vertical Coordinate System:	Australian Height Datum 1971 (AHD71), in meters
Beginning Date:	2013
Ending Date:	Current
Progress:	Complete
Update Frequency:	As required
Stored Data Format:	ESRI Shapefile format
Available Format Types:	ESRI Format
Access Constraint:	No access constraints

Lineage:

The following steps were taken in the generation of the ecological linkage axis lines:

1. Linkage axis lines as defined and identified through the SWREL project (Molloy et al., 2009) were adapted as a starting point from which additional linkage lines were added to encompass the SWCC mandated region. Minor amendments were made to the existing SWREL lines through the Jarrah Forest IBRA regions to facilitate connectivity at the regional scale

2. In areas beyond the boundaries of the SWREL project area, appropriate major watercourses for the Eastern Jarrah Forest, Avon Wheatbelt and Mallee Interim Biogeographic Regions of Australia (IBRA) regions (within the extent of the SWCC mandated region) and the Serpentine-Jarrahdale Shire were selected and added to the SWREL axis lines.

3. Within the areas covered by the Eastern Jarrah Forest, Avon Wheatbelt and Mallee IBRA regions and the Serpentine-Jarrahdale Shire two data sets were developed to inform the planning process. These were percentage of remnant vegetation per sub-catchment and average fragmentation statistic (McGarigal et al., 2009) per sub catchment.

4. The SWCC NRM Strategy Biolandscapes (Ecosystem Solutions Pty Ltd, 2009) were identified as priorities.

5. Draft ecological linkage axis lines were identified using these data sets.

6. The draft ecological linkages were then evaluated using a Proximity Analysis to assess their effectiveness.

7. Ecological linkages were reviewed, edited and finalised.

As per the SWREL methodology, the following guiding principles were used to create the ecological linkage axis lines. However it is recognised that across much of the project area there may be insufficient patches with these properties available and in such cases patches not meeting these criteria were used.

- Where available, patches should be at least 10ha in size and of good or better condition;
- Continuous stands of native vegetation with a preferred width of >500 m should be chosen where available;
- Thin remnants (<100m wide) should be avoided where it is practical to do so;
- Heterogeneity in patch structure should be sought;
- The widest possible diversity of habitat types should be sought within a linkage with similar habitats (preferably) less than 1000m apart;
- Open canopies over a highly disturbed understorey may be of little value except for highly mobile species;
- Where continuous stands of native vegetation are not available, linkages made up of patches which form stepping stones between larger intact patches should be selected;
- The target maximum between patches is <1000 m (although closer proximities between patches are preferred distances >1000m will be considered in highly fragmented landscapes);
- The greater a patch's area the greater its capacity to maintain a larger and more viable suite of species;
- The number of linkages connecting to any given patch should be maximised as this improves overall connectivity across the landscape and long-term viability of individual patches;
- Patches should be chosen whose shapes minimise edge effects;
- The potential effects of stochastic and deterministic abiotic processes (such as the impacts of wind and water movements and their potential for secondary effects such as dryland salinity, erosion and acidification) within a landscape should be considered.

As per the SWREL methodology, the following areas have been given high priority for inclusion in the linkage:

1. Patches forming the most direct links with regionally significant patches or other identified Ecological Linkage;

2. Ecological Linkages should be selected whose directions facilitate normal migration, and aid in the adaptation of species and assemblages to climate change;

3. Riparian vegetation along waterways including an appropriate buffer of non-riparian vegetation

4. Patches that enhance the viability of significant biodiversity conservation assets and initiatives through conserving both species and structural heterogeneity and therefore habitat values;

5. Patches at high points in the landscape that are in the line of sight of other patches. Line of sight is important for species dispersal and home range utilisation.

In addition, the following areas have been given high priority for inclusion in the linkage:

1. Sub-catchments with a high percentage of remnant vegetation;

2. Sub-catchments with a high average fragstat statistic;

3. SWCC NRM Strategy Biolandscapes (Ecosystem Solutions Pty Ltd, 2009).

Note: *These principles are aspirational in nature and, given the extent of fragmentation across much of the SWCC region, may not be practical in all landscapes. For example; some landscapes may not have sufficient patches with an area of >10ha or a width of >100m available to form a linkage or suitable patches may be > 1000m apart.*

Table 1: The following GIS data sets have been referred to in the compilation of these linkages:

List of GIS Data Sets Referred to			
Theme	**Title**	**Custodian**	**Meta Data Date**
Imagery	World Imagery Data Set	ESRI	Ongoing
Remnant vegetation Mapping	Remnant Vegetation	Department of Agriculture and Food WA	April 2012
Linkages	South West Regional Ecological Linkages	DEC	September 2009
Waterways	Waterways	DEC	October 2008
Hydrography	Hydrography	Landgate	October 2012
Priority Landscapes	SWCC NRM Strategy Biolandscapes	Ecosystem Solutions Pty Ltd	2009
SWCC Boundary	SWCC NRM Regional Boundary	SWCC	December 2012
Crown Reserves	Crown Reserves	Landgate	December 2012
Threatened Fauna	WA Threatened Fauna	DEC	December 2012
Threatened Flora	WA Declared Rare and Priority Flora	DEC	December 2012

Positional Accuracy: 1:20,000. This dataset is designed to be used to determine the proximity value of patches of remnant vegetation relative to the axis lines

Attribute Accuracy: Good - all populated content is known and verified by custodian

Logical Consistency:	Line work was visually checked by the authors Methodology applied consistent with published SWREL Technical Report (WALGA and DEC, 2009)
Completeness:	The dataset represent a complete suite of ecological linkage axis lines at a regional scale within the study boundary
Contact Organization:	South West Catchments Council
Contact Position:	Biodiversity Manager
Scientific Custodian Contact Position:	GIS Officer
Technical Custodian Contact Position:	South West Catchments Council
Mail Address:	PO Box 5066 Bunbury Delivery Centre
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Facsimile:	(09) 9780 6198
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Metadata Date:	12.06.2013
Other Metadata:	none