BUILDING BETTER BIODIVERSITY ON SOLAR FARMS

A regenerative guide to nature-positive solar farming

For developers, farmers, Landcarers and host communities of the New England Tableland bioregion

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About
This Guide

The Building Better Biodiversity on Solar Farms Guide (the Guide) demonstrates strategies and practical methods designed to overcome land use conflict through a biodiversity net gain approach to development and land management. It is an approach that aims to leave the natural environment in a measurably better state than it was before it hosted a solar farm. Biodiversity means the diversity of living things, including genetic, species and landscape diversity.

Drawing from both local and global experiences, this guide is tailored to the New England Tableland bioregion in northern NSW, Australia, but its principles will be widely applicable.

This Guide will help solar projects meet new and emerging drivers for better environmental performance and stewardship of the sites they lease or acquire. It will encourage partnerships with Traditional Custodians, landholders, farmers, host communities and Landcare and other natural resource management and conservation groups.

The Guide has been developed through a combination of:

- Literature review and analysis
- Interviews with and contributions from:
  - Researchers
  - Renewable energy industry leaders
  - Landowners and farmers
  - Cultural Knowledge Holders
  - Ecologists
  - Native nurseries
  - Landcare and conservation groups
- Extensive experience of ecological restoration in the New England Tableland bioregion.

The Guide is a tool that landowners, developers and consultants can use together to plan solar projects to achieve biodiversity net gain. We hope that project neighbours, host communities and Landcare groups will find the strategies within the Guide useful in helping to shape a regional landscape plan which reduces fragmentation and increases wildlife habitat connectivity. The Guide could also be referenced by regulatory agencies to gain an appreciation of potential biodiversity outcomes on proposed or operating solar farms.

sources:
map 1: environment.nsw.gov.au
map 2: energyco.nsw.gov.au
map 3: dcceew.gov.au

Focusing on the New England Tableland bioregion (Map 1) has enabled us to specifically address the challenges and opportunities of this unique environment and where it intersects the New England Renewable Energy Zone (Map 2). It is an area, too, that is in recovery from the 2019 - 2020 bushfires (Map 3).

We hope this guide will also provide a basis for action for other regions where extensive solar arrays and other infrastructure are being planned and developed.

Thank you to all those who have generously contributed to this project. It represents the meeting point of many different areas of expertise, and we value your various perspectives and openness to collaboration.

Thank you to the Foundation for Rural & Regional Renewal for critical funding support. Please see see back cover for the list of Acknowledgments and Service Directory.

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community power agency

STRINGYBARK ECOLOGICAL

Foreword:

Co-location Potential for Habitat, Wildlife and Solar

Dr Eric Nordberg, School of Environmental and Rural Science, University of New England (UNE), Armidale, NSW

Renewable energy production, particularly from photovoltaic systems (solar farms), is on the rise globally as the world shifts away from fossil fuels towards sustainable alternatives. Photovoltaic (PV) systems offer numerous benefits, including low carbon emissions, minimal maintenance requirements, and the potential to enhance land productivity and economic output, particularly on existing degraded lands[1].

Agrivoltaic (agriculture + PV) and conservoltaic (nature conservation + PV) systems are emerging as effective strategies to maximise land-sharing among industries. Conservoltaic and regenerative systems, which focus on enhancing conservation measures alongside solar energy production, offer additional benefits to solar farms by reducing solar panel degradation, ambient temperatures, and dust accumulation, while simultaneously providing habitat for native wildlife.

While solar farms have the potential to benefit wildlife and contribute to environmental restoration, the long term outcomes for biodiversity on operating solar farms remain largely unknown, especially in Australia. Similar to artificial reefs in aquatic ecosystems, solar farms have the ability to improve biodiversity, if done well. They create structural complexity in the environment, offering shelter and habitat for wildlife. Solar panels provide patches of sun and shade, which are beneficial to frogs, lizards, and snakes, and likely provide nesting and perch sites for birds.

Studies in Europe[2] and the US[3] have demonstrated that solar farms with native vegetation and wildflowers under the panels support more biodiversity than arable fields. The combination fosters plant diversity and provides enhanced ecosystem services both to native plant communities and adjacent agricultural activities through increased numbers of bumblebees, butterflies, and other pollinators.

More research is needed, particularly in Australia, to better understand the full potential benefits to wildlife of a conservoltaic approach to solar farm development, and UNE is already progressing research in this space.

Through strategic planning and the design of conservoltaic systems during the initial phases of solar farm construction, there is a growing opportunity globally to maximise land productivity, foster relationships between industries, and enhance habitat connectivity in anthropogenic landscapes through multi-purpose land use strategies. Effective management recommendations and continued research are crucial for optimising the coexistence of renewable energy production and wildlife conservation efforts.

I am pleased to have collaborated with the authors on this Guide, and my hope is that it is used widely in the New England Tablelands and beyond to make conservoltaic and regenerative practices standard among solar installations, whatever the scale.



Acknowledging
Country and Connection

Before colonial agricultural practices began to dominate the New England Tableland bioregion, First Nations people widely practiced holistic land management that included care of the land and people, combined with ceremonial practices[4]. The Anaiwan, Banbai, Dungutti, Gomeroi, Gumbaynggirr, Kamilaroi and Ngoorabul people are among those who have a long and ongoing role as custodians of this country.

Cultural heritage studies undertaken for scoping reports and environmental impact statements can uncover important sites and provide new opportunities to return the care of significant sites to Traditional Owners. Opportunities for access, care and maintenance of culturally and ecologically significant areas are possible through partnership arrangements, such as appointing site officers or ranger programs.

Speaking with Traditional Owners and other Knowledge Holders should begin early in the planning phase, guided by the First Nations Clean Energy Network's Best Practice Principles[5].

Traditional Owners undertaking renewable energy projects may also find some of these tools and strategies useful for land management practice, and we appreciate the knowledge that such groups have shared with the authors of this guide.

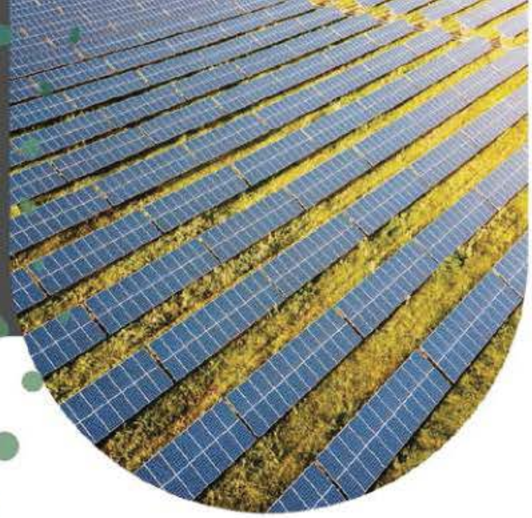
Ooralla, A protected ceremonial place on the site of the New England Solar Project, Uralla which is now maintained and cared for by First Nations Cultural Knowledge Holders. Image: ACEN Renewables

Part 1 | Purpose

Context

The increase in carbon dioxide in the air, resulting from burning coal and other fossil fuels, is one of the largest contributors to a changing climate where storms, droughts, floods and fires are increasing in intensity and severity. Weather patterns are shifting, with average temperatures increasing. All of these changes are significantly impacting the health of the New England Tableland ecological communities and species. Due to the high altitude, the Tableland is becoming a refuge for koalas and other threatened species, as increasing temperatures in surrounding regions are making other parts of their natural range uninhabitable.

Renewable energy projects are uniquely positioned to provide an alternative to the burning of fossil fuels for energy generation, while supporting carbon sequestration through healthy land management and improvements to wildlife habitat. Solar farms thereby can have a positive impact on both the short-term and long-term carbon cycles, but only if a regenerative and conservation approach to vegetation and habitat is adopted to reduce local impacts.



Benefits of biodiversity on solar farms

Securing compatible land use opportunities

Relatively flat, cleared agricultural land in proximity to existing electricity infrastructure is desirable for solar farm development. There is potential for this land use change to provide a range of benefits for biodiversity which can, in turn, improve project outcomes.

Land use associated with conventional agriculture generally has a low diversity of native species and habitat types, particularly if the land has a long history of grazing.

If renewable energy projects are designed to include measures which support and enhance local flora and fauna, there is an opportunity to increase the biodiversity and bring a range of benefits for the environment, the landowner, community and the project.

Regenerative agricultural practices can also be implemented as a compatible land use. If grazing is to be continued around solar arrays, grazing practices can be implemented that allow plant diversity and biomass to increase (see more under Intergrated Farm Management in part 3).

Reducing barriers to environmental best practice and improving project outcomes

If planned and managed well, renewable energy projects can bring a cumulative increase in terms of biodiversity to the New England Tableland bioregion, along with contributing to reduced carbon emissions and climate resilience.

Developers who have access to case studies and methods relevant to their development type will be more likely to incorporate landscape designs that deliver these co-benefits.

Demonstrating a stewardship approach to land management can assist with:

- Project planning and approval processes by demonstrating strategic justification for a project, avoidance and minimisation of environmental impacts, and an approach to reduce land use conflict.
- Addressing biodiversity impacts which can be a highly significant barrier to scaling renewables.
- Assisting developers to gain project financing, as well as to meet corporate sustainability or biodiversity net gain targets.
- Win government tenders such as REZ Access Rights.
- Future-proofing projects to meet emerging requirements to prioritise nature and nature repair, for example in the newly legislated Commonwealth Nature Repair Market.

The current planning and assessment framework in New South Wales operates on the premise that all biodiversity values within a solar farm footprint will be negatively impacted by the development. After avoidance and mitigation, these values are required to be offset under the assumption of 100% loss. Unfortunately, this approach can have the unintended consequence of removing incentive for the developer to actively retain biodiversity values on the solar farm. Under the NSW Biodiversity Conservation Act (2016), reducing the impact on biodiversity from the development will reduce the number of biodiversity credits required to offset the impact.

Harnessing co-benefits of ecosystem services

Operators of solar farms can benefit from ecosystem services provided by a conservoltaic approach. These include reduction of heat and dust, both of which negatively impact photovoltaic panel efficiency, along with erosion prevention, which can damage infrastructure.

Heat

Most solar panels perform best at temperatures around 25°C, beyond which their peak power output is reduced (known as the 'temperature coefficient'), and permanent damage can ensue from thermal stress or overloads.

Studies have found that maintaining groundcover under panels can reduce ambient heat by as much as 20% on a hot day[6].

Dust

Dust can be controlled through vegetation plantings, particularly as a buffer to dirt roads, and as part of vegetation screening and windbreak landscaping which protects panels from dominant winds and sources of disturbance, such as the ploughing of fields nearby. Vegetation also assists with visual screening for neighbours and along roads and public viewpoints.

Erosion

Planting along creeks and gullies can slow down water flows, reducing erosion and preventing damage to infrastructure while providing high quality habitat for wildlife. Groundcover vegetation absorbs water and regulates the movement of water across a site which also helps to reduce the effects of erosion around panel mounting infrastructure.

Re-connecting to Country

Cultural heritage studies undertaken during the project assessment phase aim to identify earlier land use and cultural practice by First Nations people. In many circumstances in the New England Tableland bioregion, this relationship with land has been limited or cut-off by colonial and contemporary farming arrangements. Planning a solar development is an opportunity to re-establish connection to land for First Nations people. Opportunities for access, care and maintenance of culturally and ecologically significant areas, and the broader site, are possible through procurement, employment and partnerships

Building community relationships

Host communities who understand what measures may be possible in combining land use for the purposes of renewable energy generation and environmental stewardship are better placed to engage with developers on identifying ways to enhance biodiversity outcomes through a more holistic and planned approach to landscape management. For example:

- First Nations organisations can be engaged to manage vegetation and culturally significant areas.
- Neighbours may be able to enter into biodiversity stewardship arrangements to generate biodiversity offset credits for the project.
- Wildlife corridors can be designed as part of the project to link with existing and planned habitat areas on nearby properties and reserves.
- Tree planting can be coordinated with local natural resource management groups and in the context of regional plans for ecosystem restoration.

However, care needs to be taken to ensure developers adequately fund and resource local groups who may partner on, and contribute to, revegetation projects. Importantly, local groups should not be relied upon to undertake tasks that are the responsibility of the developer, such as vegetative screening as a condition of consent where neighbouring properties are impacted by a change in their view or environment.

Solar developers should be prepared to fund revegetation works on their own project sites, from their own project budget, and/or through the project's biodiversity offset credits.

Reducing land use conflict

Communities care deeply for their local natural environment. Efforts by developers to collaborate with the community to minimise the impacts on biodiversity, integrate conservation and practice responsible land management will assist in building relationships and trust in the development process. This can help to reduce delays caused by community concern over a project's possible environmental impacts and minimise conflict.

Case Study: Biosolar Green Roof, Barangaroo

A study of two rooftop solar arrays illustrates the benefit of groundcover vegetation to both PV panel efficiency and biodiversity. A 1863m² rooftop solar installation in Barangaroo, Sydney is a fixed tilt system mounted on a green roof of predominantly native grasses and herbaceous plants.

A second rooftop solar installation of identical size nearby was not planted with a groundcover layer and is used as a comparison site.

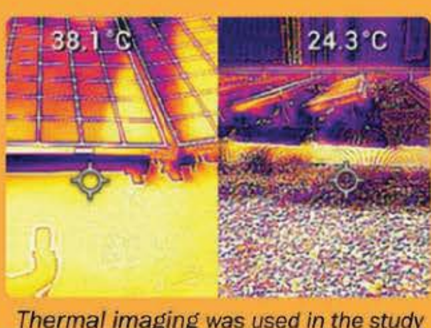
Plant species	**Common name**
Under solar panels	
Viola hederacea	Ivy-leaved Violet
Dichondra repens	Kidney Weed
Around solar panels	
*Crassula multicava**	Fairy Crassula
*Aptenia cordifolia**	Baby Sun Rose
Open areas	
Dianella caerulea	Blue Flax-lily
Myoporum parvifolium	Creeping Boobialla
Brachyscome multifida	Cut-leaf Daisy
*Gazania tomentosa**	Silver Leaf Gazania
Goodenia ovata	Hop Goodenia
Poa poiformis	Coastal Tussock Grass
Themeda triandra	Kangaroo Grass
Carpobrotus glaucescens	Pigface

This blue banded bee was photographed visiting flowers on the green solar roof at Barangaroo.

Researchers from University of Technology Sydney, Charles Sturt University and University of Canberra compared the:

- presence of biodiversity (in the form of arthropod, gastropod and avian species)
- behaviour of different vegetation types at different parts of the array
- ambient temperature, panel temperature and panel performance

Their results were published in the journal article *Biosolar green roofs–achieving biodiversity outcomes and solar power on the same roof, at the same time*[6].



Thermal imaging was used in the study to capture ambient temperature to compare the mitigating effects of groundcover (right).

"Traditional solar panels benefit from the cooling effect provided by the evaporation of surrounding vegetation, resulting in a cooler microclimate. This cooling effect lowers the temperature of the solar panels, consequently enhancing their performance.

"Excitingly, we found definitive evidence that the microclimate formed due to the native plantings, increased four times more avian species and over seven times more for arthropod species, with an obvious trophic pyramid starting to form supporting an entire ecosystem."

- Dr Peter Irga, Senior Lecturer Nature Based Solutions, University of Technology Sydney



Part 2 | Design

The principles of avoid, mitigate and offset biodiversity impacts form the basis of this Guide. However, the resources in this Guide assist renewable energy projects to go further, enabling sites to be optimised to achieve biodiversity net gain.

Underpinning principles

- Work with Traditional Owners to restore holistic land management practices.
- Minimise clearing required for project construction through design of solar arrays and other infrastructure. Locate site infrastructure in areas of low biodiversity value.
- Consider project design and landscaping in terms of broader connectivity to surrounding wildlife habitat.
- Work within the practical and technical requirements of a solar farm.
- Use the change of land use opportunity to address long standing issues such as loss of biodiversity and gully erosion.
- Implement the design toolkit in this Guide to improve biodiversity outcomes beyond existing baseline.
- Use active management, such as revegetation and weed control, to improve biodiversity across the whole site.
- Adopt regenerative grazing practices to maximise groundcover species diversity and biomass.
- Apply biodiversity offsets as locally as possible.
- Plan for long term approaches to land management that extend beyond the use of the site as a solar farm.

Design toolkit to improve biodiversity

Careful planning and design from the very early stages of a solar farm project can avoid impacts on biodiversity, thus reducing the significant costs of offsetting. It can also lead to a net increase in biodiversity values, enhance local connectivity and provide important ecosystem services locally, such as pollination, micro-climate modification and erosion control.

In this section, we outline **four design tools** to incorporate into Environmental Management Strategies and Landscaping Plans that are complementary to solar farm site uses.

1. Wildlife corridors and connectivity

The areas of a project site that are the least suitable for solar arrays and infrastructure often have the most potential for restoring wildlife habitat and corridors.

- Consider riparian zones, project boundaries, access easements, steep slopes or rocky areas for siting wildlife corridors within a broader context of connectivity.
- Engage in research to understand the habitat size and requirements of different species that use the area.
- Map the broader area and look where the project sits in the landscape in relation to existing habitat patches, corridors (such as rivers and roadsides) and restoration projects.
- Use trees and shrubs planted on the boundaries to screen views of solar farms and provide wildlife connectivity.

Design wildlife corridors to connect areas of habitat across a site and into neighbouring lands

- Consider how the animals move in, out and across the site. Corridors ought to connect to larger areas of habitat.
- Choose plant species endemic to the area and which create habitat and food requirements of key species.
- Mitigate constraints such as fencing (e.g. provide safe crossing areas with no barbed wire or consider raising fencing slightly off ground level for the passing of terrestrial animals such as lizards, small mammals or turtles near riparian zones).
- Provide nest boxes or log-hollowing for nesting of target species.

2. Native grasses and groundcovers

While trees and shrubs are likely to be incompatible amid solar arrays due to shading, ground layer vegetation can be very advantageous. In long-grazed or farmed paddocks, ground cover diversity is usually low compared to natural ecosystems. Enhancement of the ground layer vegetation can increase the diversity and cover of native species of grasses, forbs, ferns and other plants. Management of the ground layer can begin before the solar panels are installed and may include: targeted weed control, cultural and ecological burns, removing soil weed seedbanks, introducing rotational grazing with long rest periods, sowing seeds or planting seedlings.

Ground disturbance (i.e. cut and fill excavations) can be minimised by designing the solar arrays to follow the natural landforms, and by using rollers rather than excavators to prepare the land.

Opportunities include:

- Increased habitat and food for insects, birds, lizards and small mammals.
- Solar panel efficiency can be improved by regulating extremes of panel temperature[6].
- Species can be chosen for a low maximum height to prevent shading of panels and ease of access.
- Native seed banks can be established so that the native cover reproduces sustainably with genetic diversity.
- Fire retardant species can be selected or managed fire breaks included along roads, tracks and site boundaries.
- Co-benefits may include opportunities for seed gathering or cultural practices.
- Mowing and weed spraying costs can be reduced once established.
- The change of land use can be an opportunity to introduce a rotational grazing system, based on a grazing plan (see 'Management' section).

Groundcovers moderate water, heat and dust while enabling big gains in biodiversity

In South Australia, Seeding Natives and SA Water established 37ha of saltbush species under solar panels from seed supplied by Succession Ecology. The 'sponge' reduces dust, provides habitats for animals such as lizards, and has a cooling effect on the panels. Maintenance is minimal, with a maximum of one mow per year during summer (with a mower height of 200 – 250mm).

Image: Andrew Fairney

Techniques to improve poor groundcover

For areas with poor groundcover dominated by weeds or introduced pasture species, excavation machinery can remove the surface layers of topsoil where these seeds are stored. After some of this soil is removed, seeds of native grasses and groundcovers can be broadcast prior to and during the driving of piles for the mounting of solar arrays. Note that this method is only viable in areas with a very low slope (<2°) to prevent erosion. Foot and machinery traffic will help to press seeds into the soil, ready to germinate.

Soil that is removed from these areas is a valuable asset and can be used elsewhere as fill, to remediate eroded gullies, improve run-off and catchment services or shaped into linear mounds where screening vegetation can be planted. Retaining the topsoil onsite in consolidated mounds maintains the valuable soil resource whilst reducing the surface area for weed management. For sites considering long runs of vegetation screening using mounded topsoil spoil, careful design is needed to manage run-off and reduce any potential damming effects. When planned thoughtfully, this technique may be able to improve survival rates of vegetation screening plantings whilst also regulating water flows on-site and assisting with recharging aquifers.

In order to have enough seed to broadcast into scalped areas, it may be necessary to establish seedbanks of local species. Solar farm developers should work with commercial or community seed collectors to target suitable species for planting under panels and in riparian and corridor plantings.

For ground cover establishment, early site works planning is essential. Projects can establish seed production areas to grow large quantities of keystone species such as tussock grasses, spreading ground covers and forbs. These should be established early in the project to ensure sufficient seed is available. See Grassy Groundcover Case Study for methods.

Seed production areas can be established to produce enough seed to revegetate large areas.

Case Study: The Grassy Groundcover Project

The Grassy Groundcover project in Western Victoria has pioneered techniques to re-establish native grasslands in sites degraded by farming or grazing. Local seeds are collected and then volumes increased in seed production areas. The soil weed seedbank is removed by scalping and relocating the top few centimetres of topsoil, while maintaining erosion control strips. Then a diverse range of seeds of native grasses and forbs are sown directly into the ground. The resulting grasslands are close to the original grasslands in species diversity and structure, established with minimal weed competition and are very easy to maintain. Paul Gibson-Roy, John Delpratt and Greg Moore have written about the techniques developed and outcomes of this project[7].

3. Creeks and riparian zones

A riparian zone is the land that occurs alongside rivers, creeks, wetlands and drainage lines. These zones provide the critical element of water, and are a rich source of food and habitat for wildlife, while providing good growing conditions for a range of plants. As an 'edge' - that is, the interface between terrestrial and aquatic ecosystems - they are naturally rich in biodiversity when vegetated. Conversely, riparian zones are unsuitable for solar arrays and other infrastructure, as the ground is unstable and prone to influxes of water.

Therefore, revegetating riparian zones can provide significant biodiversity gains while providing ecosystem services such as mitigation of flood risks and erosion for solar farm sites that are co-located with riparian zones.

The Gara River, which flows through the site of the proposed Oxley Solar Farm, could benefit from biodiversity gains through riparian restoration.

- Planting in gullies (and increasing groundcover across the whole site) slows down surface water flow, which reduces flood speeds and height. This reduces the damage from heavy rainfall on local soils and infrastructure such as roads and bridges. It also improves water quality and, therefore, habitat value for aquatic species such as fish and turtles.
- Rocks and logs removed during construction can be added for habitat for small species such as frogs, native mammals and reptiles.
- Wet areas are problematic to install panels on, so it provides an opportunity to improve an otherwise under-utilised space.

Revegetating riparian zones enables large biodiversity gains while mitigating risks of flood and erosion

Eastern Yellow Robin

4. Habitat clusters

Small blocks of shrubs can be planted in areas of a solar farm where they will not shade the solar panels:

- Clusters of shrubs at distances of up to 80m apart can provide small woodland birds with the perches and protection needed to move freely about a site between larger habitat patches[8].
- Linkages of habitat clusters allow species to forage over a wider area with a reduced risk of predation.
- Habitat clusters connect plants and animals so gene flow can occur to reduce inbreeding.
- Pockets of land that are unsuitable for solar infrastructure can be perfect placement for habitat clusters (e.g. rocky outcrops, sections alongside tracks or the end rows of solar arrays).
- Vines such as native Clematis and Hardenbergia species can be grown up fences for an extra source of nectar for birds and insects[9].

Rocky outcrops and small pockets can be strategically planted with shrubs to increase foraging range of small birds

Species selection

Work with ecologists, Landcare, conservation groups and native nurseries to choose local species for plantings as these are most adapted to local soils and climates. Plant selection should reflect plant community types (PCTs) prior to European colonisation wherever possible, and be of local genetic stock.

GROUND LAYER SPECIES	HABITAT CLUSTERS	WILDLIFE CORRIDORS	CREEKS AND RIPARIAN ZONES
Low native tussock grasses such as Kangaroo Grass *(Themeda triandra)*, Native Sorghum *(Sorghum leiocladum)*, Weeping Rice Grass *(Microlaena stipoides)*, Barbed Wire Grass *(Cymbopogon refractus)*, Hedgehog Grass *(Echinopogon ovatus)*, Windmill Grass *(Chloris truncata)* and QLD Bluegrass *(Dichanthium sericeum)*.	Local shrubs such as Tea trees *(Leptospermum polygalifolium and L. gregarium)*, Bottlebrush *(Callistemon spp)*, Hop bush *(Dodonaea viscosa)*, Dogwood *(Jacksonia scoparia)* and Blackthorn *(Bursaria spinosa)*.  ***Dodonaea viscosa***	Eucalypts - local species chosen to match site conditions: Yellow Box *(Eucalyptus melliodora)*, Ribbon Gum *(E. viminalis)*, Snow Gum *(E. pauciflora)*, Black Sallee *(E. stellulata)*, Mountain Gum *(E. dalrympleana)*, Blakely's Red Gum *(E. blakelyi)*.	'Bendy' shrubs selected from local riparian communities -Tea trees *(Leptospermum and Melaleuca spp)*, Bottlebrush *(Callistemon spp)*.  ***Callistemon pityoides***
Clumping forbs such as Billy Buttons *(Chrysocephalum and Craspedia spp)*, Blue flax lily *(Dianella revoluta)*, Native Geranium *(Geranium solanderi)*, Native daisies *(Leucochrysum and Rhodanthe)*.  ***Leucochrysum albicans***	Small trees such as Coast Banksia *(Banksia integrifolia)*, *Pittosporum spp*, Black Sheoak *(Allocasuarina littoralis)*, and Cypress *(Callitris glaucophylla, C. oblonga or C. endlicheri)*.  ***Callitris oblonga***	Wattles *(Acacia spp)* Trees – Silver Wattle *(Acacia dealbata)*, Fern-leaved Wattle *(A. filicifolia)*, Blackwood *(A. melanoxylon)*, Western Silver Wattle *(A. neriifolia)*, Hickory Wattle *(A. implexa)*. Shrubs – Red-stemmed Wattle *(A. rubida)*, Sticky Wattle *(A. viscidula)*, Poverty Wattle *(A. dawsonii)*.  ***Acacia dawsonii***	Rushes, sedges and reeds such as: *Lomandra longifolia, Phragmites australis* or Bulrush *(Typha spp); Eleocharis spp, Carex spp, Cyperus spp or Juncus spp.*  ***Lomandra longifolia***

GROUND LAYER SPECIES

Chenopods (saltbushes) such as Climbing saltbush *(Einadia nutans)*, Goosefoots *(Chenopodium spp)*, Cudweeds *(Dysphania spp)*, *Sclerolaena spp, Atriplex semibaccata* and Ruby Saltbush *(Enchylaena tomentosa)*.

Enchylaena tomentosa

Ground covers such as Sarsparilla vine *(Hardenbergia violacea)*, Spreading bush pea *(Pultenaea microphylla)*, Aemulla *(Eremophila debilis)*.

Small shrubs such as Guinea flowers *(Hibbertia spp), Grevillea juniperina, Correa spp* and *Cryptandra amara.*

Hibbertia obtusifolia
Image: Kate Boyd

HABITAT CLUSTERS

Tall dense grasses such as Spear Grasses *(Austrostipa verticillata, A. aristiglumis* or *A. ramosissima)*, Tall Oat Grass *(Themeda avenacea)*, Mat Rushes *(Lomandra spp)* and Rushes *(Juncus spp)*.

Climbers on fences such as Sarsparilla vine *(Hardenbergia violacea), Clematis spp*, Native jasmine *Jasminum spp* and *Parsonsia spp.*

Hardenbergia violacea

WILDLIFE CORRIDORS

Local shrubs such as Tea trees *(Leptospermum spp)*, Bottlebrush *(Callistemon spp)*, Small -fruited Hakea *(Hakea microcarpa)*, Hop bush *(Dodonaea viscosa)*, Peas *(Hovea lanceolata, Daviesia latifolia, Pultenaea foliolosa)*, Daisy bushes *(Olearia fulgens, Cassinia laevis or Ozothamnus diosmifolius)* and Blackthorn *(Bursaria spinosa)*.

Hovea lanceolata

Casuarinas such as River Sheoak *(Casuarina cunninghamiana)* and Black Sheoak *(Allocasuarina littoralis)*.

CREEKS AND RIPARIAN ZONES

Tussock grasses planted on the banks such as *Poa labillardiere*, Kangaroo grass *(Themeda triandra)*, Swamp Foxtail *(Cenchrus purpurascens)*, or Umbrella Cane Grass *(Leptochloa digitata)*. Creeping semi-aquatic grasses such as Water Couch *(Paspalum distichum)*.

Cenchrus purpurascens

Aquatic plants - seek local advice about what is best for boggy areas, open water or shallow streams.

Using biodiversity offsets locally

If a development has a negative impact on biodiversity, the impacts will likely need to be offset through the purchase and retirement of biodiversity 'credits'. These are produced on offset areas with similar vegetation communities. In NSW, regulations allow offset areas to be located anywhere in the project's bioregion. Species offsets can be located anywhere in the state, well away from the site of the impact.

Offsets should be applied strategically to build connectivity between wildlife corridors and wild places.

Offsets can provide an opportunity to collaborate with landowners, neighbours, host communities, and community groups such as Landcare.

Landholders leasing land to a developer can also directly benefit by producing and selling offsets from the same property. Even cleared farmland can be used to produce offsets by revegetating and regenerating native species.

Solar farm host Richard Munsie speaks with Southern New England Landcare members about planting wildlife corridors and shelterbelts.

Areas adjacent to the solar arrays on White Rock Solar Farm (west of Glen Innes) have been set aside for revegetation as part of the project's biodiversity offsets.

Developers should try to apply offsets locally if a suitable location can be found. This means the offset occurs close to the plants, animals or communities impacted by the development.

Offsets can even be located on the same property, in areas not used for the solar array.

Part 3 | Construction, Management and Operation

Management plans

Planning for better biodiversity outcomes on a solar farm should ideally begin at a project's scoping stage. Strategies identified to contribute to improved biodiversity can be written into Environmental Impact Statements and planning documents to demonstrate that a developer is actively considering how to achieve a net gain in biodiversity when taking over the management of a site.

Environmental Management Plans, Biodiversity Management Plans and Landscaping Plans can reference different methods to be used to improve the biodiversity value of a project site, and indicate where improvements will be made. These plans are site-specific and translate the broader commitments made in the EIS into detailed and tangible actions. So more than referencing different methods, they need to be quite specific, including performance criteria, timeframes to achieve, and adaptive management measures.

Other related plans may also include those prepared for bushfire, soil and water.

Bushfire risk and asset protection zones

Firebreaks (i.e. of 10 metres or more) are required to be maintained around the perimeter of facilities, electrical compounds and substations, and are usually constructed at the start of development. Vegetation screening is often used along perimeter boundaries and is located outside the Asset Protection Zone (APZ).

It is recommended that habitat clusters (clusters of shrubs designed to assist with increasing habitat connectivity of species such as woodland birds) also have a minimum of 10 metres between solar arrays or other infrastructure when sited in the New England Tableland bioregion.

The APZ often includes roads designed for vehicles to move around a site. Crushed rock or mineral earth are often the preferred materials, or mown/slashed grass. No planting or woody vegetation should remain within the APZ. Standard development consents will also often require unobstructed access around the project perimeter for fire fighting purposes.

Rural Fire Services may include a recommendation during a project's approval process for heights of vegetation underneath panels to be maintained throughout the operation of the solar farm. Mowing can occur less frequently underneath solar panels where native grasslands have been established as they are often not as fast growing as exotic species which can reduce costs for bushfire maintenance. Seasonal variations could be integrated into management plans, such as allowing longer vegetation in late autumn, in winter and in early spring, for example, where fire risk is lowest. Vegetation height can also be managed through a grazing plan.

Construction

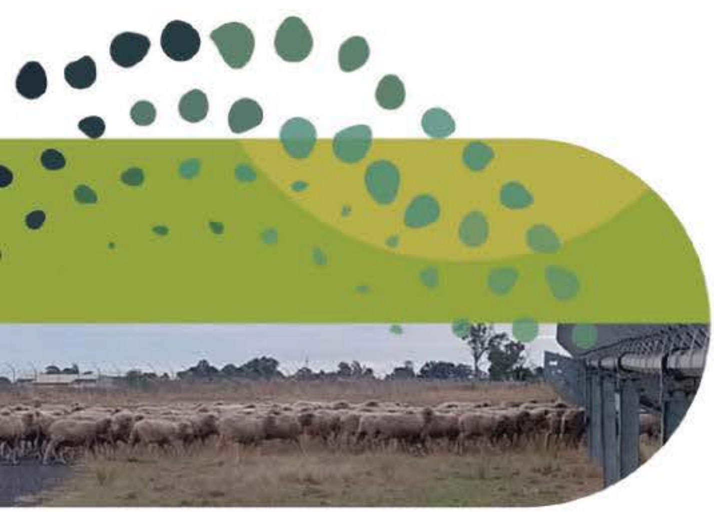
Protection of remnant vegetation is important during construction. Induction for site staff should include:

- Overview of biodiversity strategy
- Identifying areas of ecological or cultural significance that should not be disturbed
- Biosecurity measures.

Signs and temporary fencing can be used to to indicate high conservation value areas, so these are not used for temporary storage of materials or vehicle parking.

Projects should have specific management approaches to address biomass. Where trees and other woody vegetation are removed, trunks and stumps can be redistributed to the site or to nearby habitat restoration projects as hollows for nesting or for riparian zones. Trees provide important habitat for many species and provide niches to protect plants. Mulch can also be used to protect scalped or burnt areas, mulch new plantings or reduce erosion.

Where grasslands and groundcover are in fair or good condition, consider rolling as a method for preparing ground for construction over excavation. A cool burn can be undertaken prior to construction in these conditions, as it will stimulate the growth and propagation of native species, while reducing the prevalence of weeds and introduction of new weed species.



Vegetation management

Ongoing management is important for maintaining biodiversity gains and maintenance may need to be continued for the life of the solar farm.

- **Vegetation management:** Once seedlings are planted in windbreaks, riparian areas and corridors, they will need initial watering (usually only for the first few months) and weed control around them for the first 3-6 months. Later, mowing around planted seedlings can reduce weed competition.
- **Groundcovers:** Native grass and other groundcovers under panels can be mowed annually to reduce fire risk, stimulate healthy growth, and keep the plants at a manageable height. The need is likely to be less frequent than maintaining introduced grass species. Rotational grazing with sheep can also be used to keep groundcover vegetation to the right height.
- **Mulching:** It is recommended to mulch any vegetation removed and keep (safely) on site for its value to build soil, conserve moisture, and minimise competition for plantings. Mulch around plantings will cut down on the need for follow up weeding, watering and pruning.

African lovegrass 2 weeks after intensive grazing (left of fence)



Considerations for solar panel mounting systems

Tracking systems (where panels rotate to follow the path of the sun over the course of a day) provide a more even spread of sunlight and moisture as the panels move throughout the day. A wider range of grasses and groundcovers can successfully grow underneath these panels.

It is useful to consider how microclimates affect vegetation on solar farms, particularly relating to groundcover beneath or near arrays of panels. Some species will adapt better to the shade of solar panels, frost protection, and differences in moisture available in the solar farm environment.

Fixed tilt systems (where panels do not move but are instead fixed on a certain angle) will have limitations around what will grow in the shady and relatively dry conditions under the panels. See the case study on the biosolar roof on page 8 for more information on how the plantings were designed according to relative position to panels.

A wide variety of groundcover plants will grow between rows. For fixed panels in particular, the mix should include plants that are able to absorb the larger quantities of water that runs off the panels, while also facilitating access for panel maintenance.

Height of mounting racks

If sheep grazing is to be integrated into operations, a minimum panel height will be required. 2P (double panel height) may be preferred. Some on-farm solar arrays are mounted high enough for cattle to comfortably pass under, although these are generally currently limited to smaller sized projects due to the extra cost.

PEG systems

The PEG is a ground mounted system that is designed to face east-west. The design prioritises lower requirements for space and materials such as metal, and the low profile of the sub-frame minimises visual impact for neighbours. This design allows for either a bare site to minimise fire and vermin risk or a maintained vegetative surface to ensure soil stability and erosion control depending on the solar farm location.

Vegetation (ryegrass) growing beneath a PEG array at the Junee Solar Farm

Image: Meralli Solar

Designing on contour

Designing a solar project with a topographical map overlay enables arrays, fences and laneways to be designed along contours.

Farmers practicing regenerative agriculture practice keyline design (based on contours), to manage water flow and maintain soil fertility. These principles can be adapted for integrated farm management that include solar generation land use. When designing a solar farm that allows for grazing of sheep, while improving soil, groundcover and biodiversity, an approach that makes use of the natural features of the land will get better outcomes for all three land uses simultaneously.

On-contour design can also mitigate effects of fixed tilt systems where rainfall is concentrated beneath the lower edge of the panel, possibly causing erosion or wet areas..

Integration with farming operations

An approach of 'working with nature' should be taken to successfully farm both the sun and the land. If the hosting of solar infrastructure is to be combined with sheep grazing, discussion and planning needs to commence early to determine how to make the most of these collaborative land uses.

Sheep can be managed by the host landowner, or could be agisted and managed by a neighbouring farmer or by sharefarmers (who may not have their own land to farm).

Merino sheep and merino crosses are most commonly used in agrivoltaic operations, but Australian Whites, Dorpers and other shedding sheep are successfully used when attention is paid to any surfaces that would be problematic should a sheep rub against them (e.g. fitting guards to rotating mechanisms). Refer also to resources such as Clean Energy Council's Guide to Agrivoltaics[10].

Paddock design
Permanent or movable water sources (i.e. troughs) can be included in paddock design. Movable water sources, fencing along contours and regularly rotating sheep through paddocks ensures that sheep don't form 'sheep camps' or 'wear down' certain areas of pastures.

Water tanks can be placed on the highest part of a site. Water can be pumped from a water source such as a dam by a solar pump, and will be gravity fed into different paddocks.

Fencing plan
A fencing plan with laneways will ensure sheep can be moved easily from cell to cell, generally with the help of an All Terrain Vehicle (or horses) and sheepdogs. Consider the safe movement of ATVs, people and horses when designing solar infrastructure (eg avoid rotating mechanisms that are fitted at ground level). Whistles can be used to help train sheep initially as they get used to paddocks, and drones can also be used. Electronic ear tags and virtual fencing may be able to be incorporated into future design of fencing plans.

See also page 21 for considerations around perimeter fencing and movement of wildlife.

Grazing plan
A grazing plan will assist landowners to rotate stock according to density of biomass of the groundcovers and native pastures, and according to weather and stock conditions. The grazing plan will help maintain optimal groundcover height beneath panels, while also managing issues such as parasites.

Diverse native grassland

Case study Lana Station: Regenerative grazing

Tim and Suzanne Wright run 3000 breeding merino ewes and 650 breeding cows on their 3300ha property at Balala, west of Uralla within the New England Tableland bioregion. They use planned grazing practices and paddock design to naturally maintain high ground cover, increase the volume of cool and warm season native species and build up soil carbon.

Livestock are intensively grazed in mobs through smaller paddocks of average size 10 hectares or less. Pastures have long rest periods before they are grazed again. This method works with nature rather than against it; increasing stock density per hectare and reducing farming inputs. The holistic grazing plan system guides decision making about when and where to move livestock, based on the biomass in the pasture and seasonal conditions. The system creates opportunities forrare species to increase and prevents any one species from dominating the ground layer.

Over the 35 years Tim has been managing this way, he has seen species such as Kangaroo Grass and Short-haired Plume Grass increase, while less favourable species such as Wire Grass have decreased.

Biosecurity

Weeds of National Significance such as serrated tussock and Chilean needle grass are found throughout the New England Tableland bioregion and are easily spread from property to property.

Supporting wildlife habitat

Wildlife displaced by reduction of habitat due to removal of trees or areas of vegetation should have alternative habitat established close by. This could be through revegetation with added habitat features such as nest boxes, rock piles, or logs on the ground, including any hollow salvaged from any clearing undertaken. Solar farm developers should work with neighbours (including government or crown land) to improve the quality of existing surrounding bushland so it can support additional animals displaced by development. Animals found in trees needing to be removed from the site should be relocated to the nearest suitable areas. Solar developers should ensure that anyone working with wildlife is suitably trained, and that local wildlife carer groups are supported to prepare for the possibility of additional assistance being required as animals adjust to changes in their environment.

Nest boxes should be designed to meet the specific needs of the species being displaced. Guidelines are readily available and commercial suppliers can be found in most regions. Construction of nest boxes could also be done in partnership with local schools or men's sheds. Logs provide important habitat for many plants and animals, including providing unique microclimates. Any logs or stumps that need to be cleared from the site should be redistributed and spread throughout the area.

Landscape planning for habitat enhancement should be discussed and planned prior to construction. Opportunities for restoration may arise from 'avoidance areas' within the solar farm lease/project area. Alternatively, the developer may come to an arrangement with neighbouring property owners to relocate habitat features removed during construction.

Large scale solar farms with a patchy distribution of panels and intermixed natural areas (undisturbed grasslands, shrub rows, old paddock trees, riparian buffers around waterways) should provide strategic connectivity and travel corridors for wildlife.

Fencing and access

Perimeter fences are usually designed to exclude humans or livestock but can have unintended effects on wildlife. When designing perimeter fences, consider the movement of wildlife across the landscape. Simple construction modifications, such as leaving a gap of 50mm under fences enables animals such as turtles to move across sites. These openings can be small enough to prevent larger predatory animals such as foxes, or damaging animals such as pigs, from entering. Additionally:

- Fences should be checked regularly to ensure any access points are not covered by debris.
- Posts can assist animals such as gliders or koalas to move across high security fencing.
- Monitoring is recommended to see how different animals are accessing the site over time.

Internal laneways between sets of arrays and project infrastructure, which help with movement of people, vehicles and stock around a site can also be designed to allow access for larger animals such as kangaroos, and kangaroo gates are recommended to help designate easy crossing points and prevent damage to fences.

Barbed wire on top of fences can catch and kill animals such as bats, owls and gliding possums, especially if the wire is on a ridge and therefore above the horizon.The use of barbed wire should be limited to substations as per Australian Standards 2067:2016 regarding Restriction of Entry (point 10.4; AS 2067-1984) and avoided for perimeter fencing of solar farms where possible. Where barbed wire fencing is used, a high visibility wire run across the top can help to increase visibility and prevent collisions from wildlife. This could be specific to requirements of different parts of a site, and supported with research and monitoring.

Injured wildlife

Develop a plan to manage any wildlife injured during construction or operation. Work closely with local WIRES or wildlife carer groups and ensure all staff and contractors know what to do if an injured animal is found on site.

Decommissioning

Solar farms are operational for around 25 - 30 years before they are either refurbished (with updated components as required) or decommissioned, which involves removing solar arrays and other infrastructure from the site. Solar panels should be repurposed or recycled in an accredited facility that can safely manage the different components of the PV panel.

Developers and landowners (in situations where land is leased for a project site) should consider how biodiversity gains can be maintained long term. While conditions of consent for a project will usually include a clause that all materials are removed and the site is returned to former use, it may be beneficial to leave areas fenced off (such as around riparian zones) and to adjust intensity of grazing practices to enable native groundcovers and pasture grasses to continue to thrive.

Landholders and developers should mutually agree on which infrastructure, such as additional water points and internal fencing constructed for cell grazing, are retained after decommissioning. If paddock trees and shelterbelts have been removed in the construction period, these should be replaced after decommissioning so stock can be adequately sheltered.

Another alternative to reversion to original land use after project decommissioning could be the listing of the site under a Conservation or Stewardship Agreement with the Biodiversity Conservation Trust.

Biodiversity net gain and nature positive legislation

This Guide provides means for innovative developers to future-proof their developments and streamline the approval process by going above and beyond current legislated requirements, achieving increases in biodiversity while enjoying the benefits of ecosystem services and building constructive relationships with host communities.

In NSW, developers must assess the impacts of their project on biodiversity by using a standard method to assign a score to the condition of the biodiversity before the project starts and after it is completed. Similar schemes exist in other states. In NSW, the Biodiversity Assessment Method (BAM) is used to calculate a Vegetation Integrity Score (VIS). The assumption is usually made that after development, the VIS will be zero. It may be possible to minimise the reduction in the VIS by implementing some of the measures in this Guide, including improving ground cover under the panels, planting riparian zones and planting corridors on the boundaries. When integrated with such an approach, the project could even lead to a net gain in biodiversity on the site, providing large areas of trees and shrubs are not cleared in the process. Any reduction in the VIS must be offset by the purchase of credits, which can add considerable cost and time to the project.

Recent and emerging legislation is setting higher standards for conservation around projects, including solar farms. These include:

- Biodiversity Net Gain legislation in the UK
- Nature Positive Planning
- National Environmental Standards.

Additionally, the Mayors of the Local Governments of the New England region have called for biodiversity offsets to be used locally, and wish to see net biodiversity gain (as opposed to loss) associated with renewable energy developments in their Local Government Areas.

This Guide will assist in future-proofing solar farms to meet these emerging obligations for projects to be nature positive, as well as climate positive.

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Anaiwan Ranger Program

newaracorp.com

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