Introducing…

Whole of Paddock Rehabilitation

A new approach to regreening the farm

Greening Australia's **Whole of Paddock Rehabilitation** (WOPR) offers an innovative approach to combat increased land degradation problems by restoring paddock health and providing a range of benefits to farm production. Incentives for large-scale native plant revegetation, coupled with a fixed-term stewardship payment, will help land managers to better address the effects of climate change, biodiversity loss, paddock tree decline, salinity and other land degradation issues. WOPR integrates conservation and production in a practical, cost-effective and user-friendly program.

Key features of WOPR

- A five-year agreement to rest a paddock of at least 10 hectares from production.
- Incentives to establish widely-spaced direct-seeded tree belts on the contour.
- A stewardship payment towards production loss until stock can be re-introduced under a rotational grazing system.

Once the trees are big enough, stock can be returned to the paddock. There is no land lost from production.

Australian Government

Greening Australia

Contents

This Whole of Paddock Rehabilitation booklet is divided into three sections.

What does WOPR involve?

Step 1 Talk to Greening Australia (GA) about your eligibility and, if appropriate, organise a site visit with one of GA's WOPR field staff to discuss a management agreement for incentives and stewardship support.

Step 2 Identify a suitable paddock of at least 10 hectares (preferably 20–50 hectares). Alternatively, a larger existing paddock can be sub-divided according to land class to create an appropriate WOPR paddock.

Step 3 Prepare the site according to the advice provided and an agreed design. GA will organise for the appropriate species of native trees and shrubs to be direct seeded in widely-spaced alleys along the paddock's contours (e.g. four treelines separated by 40–50 metres for pasture). The project will provide the full cost of seed and seeding.

Step 4 Rest the paddock from grazing for a five-year period. A stewardship payment of $50/hectare/year will be offered following seeding, with 50% paid in years one and five respectively.

Step 5 After five years, the trees should be large enough to cope with grazing animals which can then be re-introduced under a rotational grazing system.

Whole of Paddock Rehabilitation, 12 years after seeding.

Who is eligible for WOPR?

Whole of Paddock Rehabilitation is designed to integrate large-scale revegetation into commercial grazing or mixed grazing enterprises. The WOPR program aims to attract **primary producers (graziers)** who derive most of their income from the farm.

The innovator behind WOPR, Leon Garry addressing participants at a field day on his property 'Weilora'.

Participants in the WOPR program will be required to:

- Fill out and submit a WOPR application.
- Sign a five-year management agreement which includes a strict grazing exclusion.
- Commit to the agreement on the understanding there is no intention to sell the property for the duration of the agreement.
- Use direct seeding for revegetation wherever possible.
- Undertake site preparation, fencing and pest management as required.
- Host field days or open farm days as requested.
- Undertake simple photo monitoring and recording at the site.
- Allow for detailed monitoring and evaluation by GA staff and volunteers.
- Notify GA staff of any changes or concerns at the site.
- Participate in surveys as required.

WOPR agreements represent a partnership towards environmental restoration and are designed to achieve mutually beneficial outcomes for both production and conservation.

What are some of the benefits of WOPR?

Whole of Paddock Rehabilitation is designed to deliver both production and conservation benefits including the following.

Livestock production

- Improved weight gain and performance from increased shade and shelter.
- Reduced mortality of lambs and off-shears.
- Additional feed source for livestock during summer through ingestion of Acacia pods and foliage (see page 19).
- Increased resistance to internal parasites (worms) through consumption of Acacia pods.
- Return of pasture to heavily eroded or saline areas.
- Improved soil stability and soil health through nitrogen fixing and nutrient cycling.
- Improved native and perennial pastures.

Nature conservation

- Little to no fencing and cost-effective revegetation.
- Regeneration of remnant vegetation, paddock trees and native grasses.
- Increased native habitat and biodiversity, especially for birds.
- Sizable 'stepping stones' to connect patches of remnant vegetation.
- Future seed sources for further revegetation.
- Increased carbon sequestration to alleviate impacts of climate change.
- Reduced spread of wind-borne weed seeds.
- Less salt and sediment entering creeks and rivers.

Direct seeding has revived dying paddock trees.

Will's WOPR paddock

A hypothetical case study

William Seed has a 1200-hectare grazing enterprise in the Crookwell district. During a site visit in 2012 by WOPR field staff, Will identifies half of a 60-hectare paddock as a suitable site for direct seeding. The area consists of predominantly native pasture with some erosion and salinity problems.

Will's five-year management agreement, incentives and stewardship payment will include:

DSE: dry sheep equivalent
ha: hectare
km: kilometre
m: metre

• Sub-division fencing (conventional), 700 m @ $3000/km =	$2100
• Direct seeding in early spring, 30 km seeding @ $200/km =	$6000
• Stewardship payments of $50/ha/year = $50 x 30 ha x 5 years =	$7500 total
Total package =	$15,600 or $520/ha

Stewardship payment of 50% of total ($3750) paid in years one and five.

Will's contributions (estimations only)

• Site preparation for seeding. Weed and pest animal control. Estimated value of labour and materials	$500
• Additional fencing materials and labour. Estimated value of time and labour	$4000
• Percentage loss of grazing production 1.2 DSE (of ~2.2) $60/ha/year =	$9000
• Standard regulatory responsibilities	
Estimated value =	$13,500 or $450/ha

2012 timetable

- March: Paddock identified and agreement signed.
- April: GA staff mark contour lines across paddock. Will sprays 1.5 m seeding strips with glyphosate to reduce competition for future seeding.
- May–July: Paddock is grazed and fencing completed.
- August–September: Seeding strips re-sprayed and site direct seeded with 30 km of treelines.
- October: Will receives first stewardship payment.

2012–17 timetable

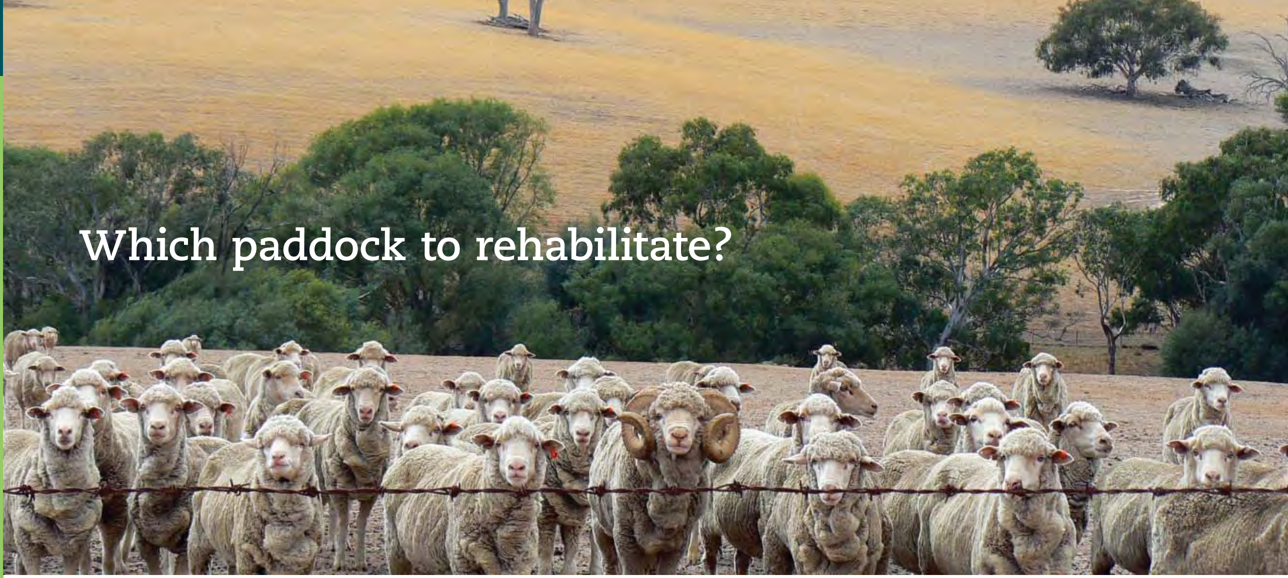
- Paddock is spelled from grazing.
- Trees, shrubs and grasses germinate and grow.
- Slashing or hay cut between alleys to reduce fire risk and weed burden if required.
- Final stewardship payment received in November 2017.
- Livestock re-introduced under rotational grazing system.

Ongoing

- Site is available for monitoring and evaluation under the program.
- Site is available for field days, tours and site visits.

WOPR in the landscape

Traditionally conservation actions have focused on the fencing of remnant bush and riparian zones, corridors and windbreaks. WOPR has been designed to fit into the agriculturally productive part of the landscape.



Which paddock to rehabilitate?

Whole of Paddock Rehabilitation is best suited to the rehabilitation of 'tired' paddocks. It may be light hilly country, often with few remaining trees, sparse groundcover or degradation issues such as waterlogging, salinity or erosion. WOPR paddocks may be chosen to alleviate salinity problems lower in the landscape. Weed-infested paddocks will be assessed and considered for likely germination and direct-seeding success on a paddock-by-paddock basis.

The stewardship payment is designed to contribute to the cost of loss of production, but is unlikely to fully offset the loss of grazing production on many sites. Approximately 1 dry sheep equivalent (DSE) or $50/hectare/year is provided.

How is WOPR different to other incentive programs?

There are currently a number of incentive projects aimed at improving production and addressing issues of salinity, water quality and biodiversity. Traditionally these projects offer fencing and revegetation incentives for windbreaks, waterways, remnant vegetation and perennial pastures. WOPR's unique features include:

- The whole paddock is rested and revegetated with little or no fencing.
- Stewardship payments are made to farmers to compensate for some loss of production.
- It addresses issues of groundcover, erosion, shelter or weeds at a paddock scale within a farm plan.

This paddock is WOPR candidate.

How and what is established in the paddock?

Direct seeding

Direct seeding is the proven revegetation method for WOPR. It is cost effective and well suited for larger areas. Since it requires significantly less labour, it can be done for a fraction of the cost of tubestock planting.

For example, a 20-hectare paddock seeded at a density of 750 metres/hectare grows on average six stems per 10 metres (Rayner 2010). At $200/kilometre this costs $3000 for 9000 stems, or 33 cents per tree. Direct seeding of a 20-hectare paddock, including seed preparation and mixing, would typically take less than a day. To achieve the same stem density with tubestock it would take about 45 days to plant (based on 200 plants per person per day) and at $2 per plant would cost $18,000… not taking into account tree guards or watering if required.

Direct seeding is particularly successful in open country on hilltops or break-of-slope areas, or areas with low to moderate fertility where there is less competition with weeds and grasses. Direct seeding may also be more resilient during drought as the seedlings only germinate in good conditions and self-select for the strongest individuals at a particular site.

Site specific design

A range of up to 20 tree and shrub species native to the local area will be seeded. This usually consists of eucalypts, casuarinas, wattles and bottlebrushes. Wattles and other pea species are used to help repair the soil as they fix nitrogen. The direct-seeding design will take into account paddock shape, slope, topography, landmarks, access and management. Alleys will generally consist of four treelines with a variable spacing of between 40–50 metres. This distance can be manipulated to suit farm machinery and stock management, while maximising shade, shelter and landscape function.

What will it look like?

Initially, the paddock may have up to 25% cover in widely-spaced alleys. Fast-growing and short-lived species such as wattles tend to dominate in the first few years, but as these begin to senesce and thin out the percentage of cover will reduce, resulting in a more open woodland system of about 60 trees per hectare. See photos page 12. The shrub layer can be maintained by allowing natural regeneration through rotational grazing, or a cool burn to stimulate germination from the seed bank.

SECTION 2

CASE STUDIES

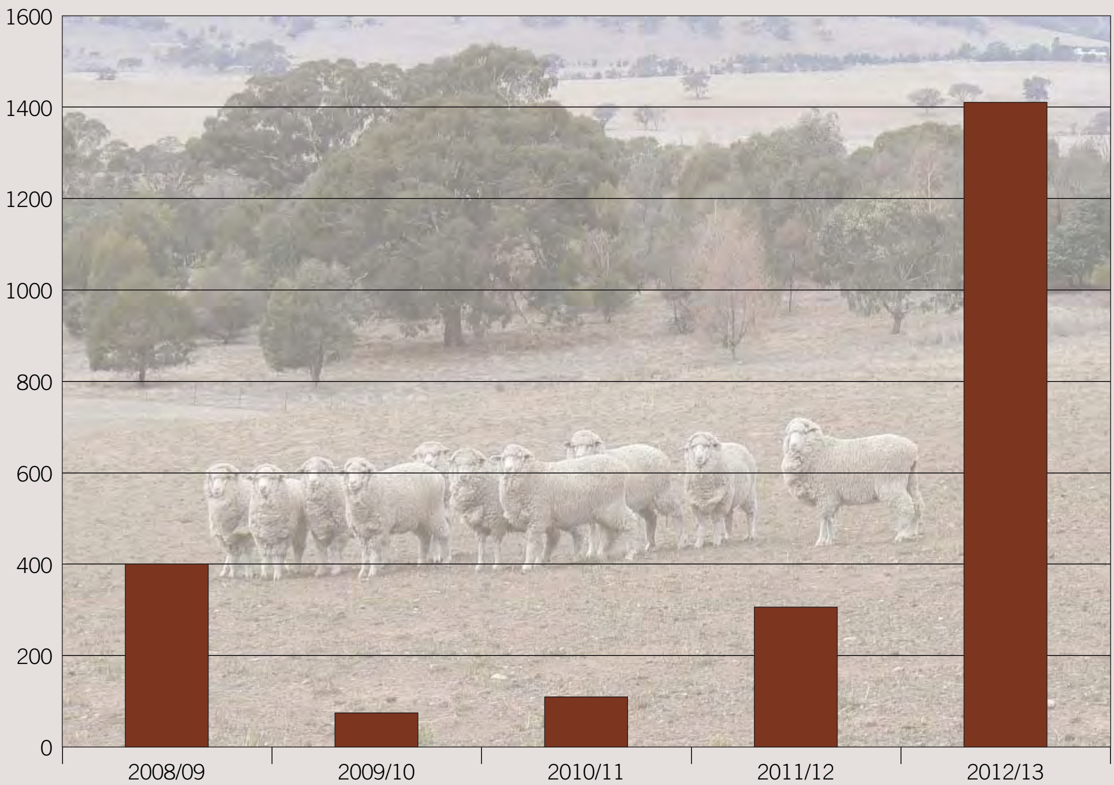
The first WOPR pilot sites were established in 2008 and have now reached the end of their five-year stock exclusion period. All participants responded positively to the WOPR concept and the package of incentives, and all carried through with assessments, management agreements and on-ground works. The success of the program is now clearly visible, with benefits to both production and biodiversity. More than 80 landholders have now signed up to the program. The next few pages contain case studies and testimonials from several of the early sites.

Since 2008, the WOPR program has achieved:

- over 80 participants
- 2300 hectares of revegetation (25-hectare average paddock size)
- 1300 kilometres of direct seeding
- 27 kilometres of fencing
- $460/hectare average on-ground cost.

WOPR has been funded by the Lachlan Catchment Management Authority; NSW Department of Environment, Climate Change and Water; and the Federal Government's Caring for our Country and Biodiversity Fund programs.

Hectares rested for rehabilitation by WOPR in NSW between 2008 and 2013



CASE STUDY

'Salt licked'—a paddock in Binalong, NSW

Based on a report by Louise Hufton, Binalong Landcare Group, 2002

Salinity is measured by electrical conductivity (EC) which is expressed as deciSiemens per metre (dS/m).

ppm: parts per million

The **'salt licked'** paddock in Binalong is like many across the Southern Tablelands. It was heavily cleared during the 1950s and subsequently sown with clover, ryegrass and phalaris to increase carrying capacity. Before long, erosion spread across the paddock and although contour banks were installed, many later failed. Bushfires in 1989 killed many of the remaining scattered trees and contributed to a rapidly rising water table and dryland salinity.

By 1994 the salt levels across the 30-hectare paddock had reached 2–3 dS/m (~1600 ppm or ~2500 EC). Salt scalds appeared and salt-tolerant grasses and rushes replaced desirable pasture grasses.

The solution to declining paddock productivity came in the form of direct-seeded native trees and shrubs. Some 40 kilometres of direct seeding was established in 1994 in widely-spaced alleys along the contour. By 1996, salt levels started to decline and by 2001 the problem had all but disappeared. Final soil tests showed salt levels of only 0.05–0.07 dS/m (~40 ppm or ~60 EC) or less than 5% of the original levels. This result was so impressive and surprising that it was re-tested three times, all yielding the same results.

The paddock has been transformed. The salt scalds have disappeared, replaced by desirable native pasture species. Old eucalypts, which were almost dead from the salt and insect attacks, are once again flourishing and the area is now alive with birdlife.

Above right: The direct-seeded treelines in 1994. Right: 'Weilora' in 2005, some 11 years after seeding.

CASE STUDY

A peek at the pasture, Binalong, NSW

So, what pasture species are present in the 'salt licked' paddock now that the salinity is under control and the paddock has been rested, revegetated and is set stocked?

Visual pasture surveys were undertaken at the WOPR paddock in the summer of 2008/09 along a number of transects on a grid running perpendicular to the tree belts (see below right).

The survey results showed that native grasses had re-colonised the paddock and were dominated by Wallaby and Corkscrew Grass. Despite the constant stocking pressure (~5.8 DSE/ha) there were very few weeds.

Desirable native grasses such as Red-leg Grass and Weeping Grass were also present during the survey. These grasses were observed to be preferentially grazed, which is likely to be the result of the set-stocking regime. Under this management system Kangaroo Grass was barely present which is consistent with observations that it does not tolerate continuous grazing (Langford et al. 2004).

How does my stocking regime affect pasture composition?

Livestock aren't that different from you and me. They have their favourite foods and will choose to graze the tasty and nutritious plants over those that are less palatable or toxic. If given a choice they will repeatedly graze the 'best' plants, limiting the plant's ability to get light, nutrients and water, and this will eventually kill them. Stock then move on to their next preference and so on. Thus the issue with set stocking is that if the duration of grazing is long enough, or stocking pressure heavy enough, the 'best' plants will eventually be eaten out, resulting in only the **least** palatable plants (often called weeds) persisting.

Top: Aerial view of the 'salt licked' paddock three years after seeding. Above: In 2013.

The pasture survey in 2008/09.

A peek at the pasture
continued

Under the moderate stocking rate of 5.8 DSE/ha at the Binalong paddock we can see that Red-leg Grass and the highly nutritious Weeping Grass were being grazed preferentially over Corkscrew Grass, which is of relatively low nutritional value, and Wallaby Grass, which although very nutritious, was seeding and browning off. The absence of weeds in the paddock suggests that the stocking rate in this instance was appropriate.

Management implications

When it comes to pasture, there is no single magic grass that produces nutritious green feed all year long, is drought resistant and tolerant of our low fertility or acid soils. In combination, however, there are a handful of productive native grasses which fulfil these requirements.

Wallaby, Common Wheatgrass and Weeping Grass are shade tolerant and provide good quality green feed during winter and spring. To increase the density of these species they should be allowed to seed up to the end of spring. In the case of Weeping Grass its high protein content (≥20%) greatly improves pasture productivity.

Red-leg Grass and Kangaroo Grass (pictured above) are not generally considered highly nutritious, but as summer-growing grasses they can provide green feed when most other grasses have died or browned off. To increase the number of these grasses they should be allowed to set seed during the summer months. Depending on the desired end result, the timing and intensity of grazing can be manipulated to increase the number of particularly desirable native grass species. This is the basis for most rotational grazing systems.

The rest and restoration afforded by the WOPR approach has created an environment conducive to re-colonisation by native pasture species. Manipulation of stocking numbers and duration (i.e. rotational grazing) could further improve the diversity, resilience and productivity of native pasture. This is part of the reason why GA recommends that WOPR paddocks are rotationally grazed from years six to 10.

Before WOPR

Improved pasture → Fire → Tree loss → Rising water tables → Salinity → Additional tree loss → Salt scalds → Salt tolerant pasture species

After WOPR

WOPR rest and revegetation → Lowered water table → Reduced EC levels → Native pasture colonisation → Grazing → Grazing tolerant native pastures

CASE STUDY

Chris and Margot Shannon, 'Talmo', Bookham, NSW

The Shannon's WOPR paddock in 2013 and inset, the same paddock in 2008.

'Talmo', a 1440-hectare property near Bookham is owned and run by Chris and Margot Shannon. Chris and Margot were among the first landholders to trial the WOPR method in 2008, choosing a 30-hectare paddock in some of the highest and coldest country on the property. "When you get into the middle of winter and the winds are howling across there and you get a bit of rain it is so cold. I've spent many a day there just thinking this is one of the coldest paddocks on earth" said Chris.

The Shannons were attracted by the low cost and effort involved in the WOPR program. "The thing we love about WOPR is that we don't have to do any fencing so there's a lot of costs saved there. We can just sow areas across the whole paddock so we're getting a lot more trees for a lot less money spent." The paddock was direct seeded with native trees and shrubs, provided as a service by Greening Australia. It was then rested for five years, during which Chris was partially compensated for the loss of production with a stewardship payment. Now that the trees and shrubs are large enough to withstand grazing, the paddock can be restocked on a rotational basis.

"The funding that we got from Greening Australia to make up for the loss of production didn't cover the whole loss, but it went a long way towards it and we're happy to put a bit in financially to make sure it's a success because we get a big advantage out of it."
Chris Shannon

CASE STUDY

Dave and Jenny Hewlett, 'Blackburn', Yass, NSW

Dave and Jenny Hewlett run 'Blackburn', a 728-hectare property with a self-replacing Merino flock, joining around 2600–2800 ewes each year. Dave started planting shelterbelts around 32 years ago, first with pines and later with native trees and shrubs. "The time that I realised we needed windbreaks on the property was when we were losing sheep", Dave said. In 2010 Dave and Jenny signed up to the WOPR program. A large paddock was direct seeded with rows of native trees and shrubs, interspersed with wide swathes of pasture. Previously, the paddock was unusable due to its exposed position, but now Dave says "ewes with lambs actively seek out the windbreaks", and the lambing percentage for twinning ewes has increased to over 140%.

"That's the beauty of it, the fact that they are windbreaks within the paddocks. It's not as if the paddock is completely turned over to a forest. You've just got trees sown in here which are going to increase productivity plus bringing back wildlife so that the paddock becomes a useful enterprise again."

"It's having a fantastic impact both on the bottom line and on the fact that genetically our flock is becoming more fertile."
Dave Hewlett

CASE STUDY

Tony and Jenny Magee, 'Gunyah', Rye Park, NSW

Tony and Jenny Magee own and manage a 550-hectare mixed farming enterprise including sheep, cattle and dryland cropping. Over the past 10 years they have transformed a degraded salinity-affected landscape into a productive system with a focus on sustainable agriculture. Originally two paddocks, they divided the farm into more than 15 paddocks and implemented a rotational grazing system, installing vegetation corridors between paddocks to provide shelter. They also fenced eroding gullies, creeks and salt scalds from stock, as well as remnant vegetation.

WOPR was a natural fit in the Magee's farming system. They removed grazing from one of the 20-hectare paddocks, and GA direct-seeded 17 kilometres of trees and shrubs in swathes along the contour in 2009. The results have been spectacular with the return of a diversity of perennial native grasses and strong growth of the seeded vegetation. Of the works, Jenny said they are "very happy with the results and we can see an improvement in the landscape as well as the bottom line".

In 2009.

"What started me on this tree planting journey was the interception of water on the surface and underneath. We still have the salt but nowhere near as bad, and we've had two wet summers."
Tony Magee

In 2013.

Direct seeding on (or along) the contour

One drawback of direct seeding is the potential for washouts to occur when seeding lines run straight up and down a slope which is often how windbreaks are placed. During heavy rain, large amounts of top soil and seed can be loosened and carried to the bottom of the hill or nearest drainage line.

Precision seeding

Direct seeding 'on the contour' slows or eliminates the movement of water along seeding lines, reducing the chance of washouts to near zero.

During rainfall events some rain is absorbed into the soil and the remainder runs off the soil surface into gullies, creeks and dams. By direct seeding on the contour, run-off can be collected or 'harvested' within a trench allowing it to soak into the soil. In this way, the amount of rainfall that finds its way to seeds and newly emerged trees and shrubs is greatly increased. This can be especially important in environments where moisture is limiting both germination and growth.

Where is the contour?

The method used to follow the contour is based on a simple homemade 'level-ometer' by Leon Garry. This device uses the simplest and cheapest of items, namely a pipe, a few cable ties, a bracket and water. The clear length of agricultural pipe is bent into a 'U' shape and partially filled with water. The flow of air or water within the pipe needs to be hampered to stop it sloshing around. The device is fitted to the vehicle from the rear to the front. It is calibrated when the vehicle is level by sliding a cable tie up or down to the level of the water within the pipe. When seeding, simply adjust the vehicle so that the water aligns to the cable tie.

Above: Using the level-ometer direct seeding can be done accurately on the contour.

Right: A level-ometer.

Monitoring WOPR on the ground

To better understand the impacts of WOPR on the ground and in the landscape, GA developed a comprehensive monitoring program.

So what are we monitoring?

The four major themes being monitored and evaluated are:

1. Bird abundance and diversity.
2. Vegetation composition and structure
   - groundcover composition
   - mid-storey and over-storey plant survivorship, stem density and species composition.
3. Paddock tree health.
4. Soil function processes — nutrient recycling, infiltration and soil stability.

How is it being monitored and evaluated?

The five baseline assessment procedures adopted are:

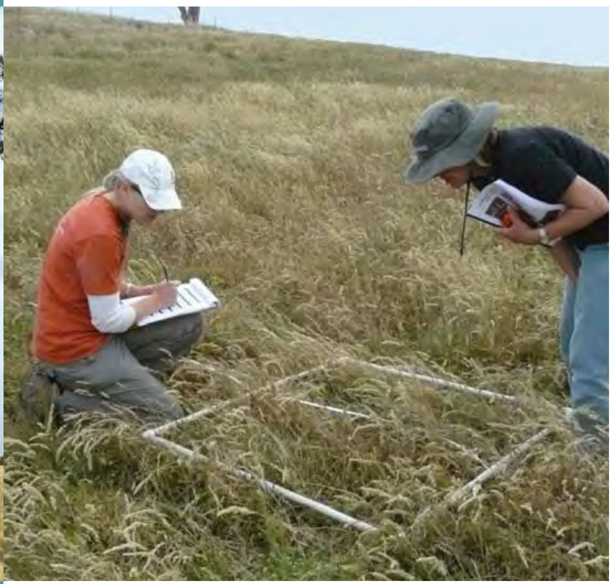
1. Groundcover analysis.
2. Landscape function analysis to measure soil processes.
3. Paddock tree health.
4. Bird atlas survey methods.
5. Modified biometric surveys to assess direct-seeding stem density and species.

Each WOPR site selected for monitoring was paired with a control site enabling comparisons between treated and untreated sites. Control sites selected exhibit similar physical characteristics and historically similar management, usually in an adjacent paddock.

The monitoring program will run in perpetuity, tracking change over time but starting as soon as practicable after the direct-seeding treatment to guarantee quality baseline data. Selected sites will be monitored every few years for change, with progressive results made available to the community.

Right: Bird survey.

Below (left to right): Paddock tree health, vegetation composition assessment, landscape function analysis.



Wattle it be?

Based on an article in the Acacia Study Group's newsletter, no. 113

A sheep farmer in south-east New South Wales, Leon Garry, revegetated a whole paddock (about 30 hectares) in widely-spaced alleys using direct seeding. He found the wattles grew quickly from seed and he soon had a 30-hectare paddock with a variety of wattles and box trees growing in lines across the contour.

Over time, Leon observed his sheep would seek out the fallen wattle pods during the summer months before the autumn break refreshed his pastures. In one wet summer, 15 sheep grazing in a largely treeless paddock next to his trees died from Barber's Pole worm. The sheep grazing among the dense lines of wattles however, showed greater resistance to the parasites.

Graham Fifield, now a Project Manager with Greening Australia in the ACT, was involved with the revegetation project through his university honours degree. He was aware that wattle pods and leaves had tannins in them, and understood that these tannins had anthelmintic (anti-worming) properties. In fact, tannin extracts from wattles have been used in drenches in parts of Africa with promising results (Max et al., 2003).

It seemed plausible then that Leon's wattle-fed sheep were less susceptible to worms than their counterparts grazing on pasture alone. This prompted Graham to initiate further research on the subject.

He collected a range of foliage and pod samples from the local wattles, and sent them to the laboratory of Dr Dean Revell, of the 'Enrich' program in Western Australia.

Dr Revell analysed the samples for their nutritive content and found the pods have a dry matter digestibility of 39–49%, and the foliage 44–52%. The samples then went to Brisbane to Dr Andrew Kotze (CSIRO) who looked at their effect on a range of parasite life stages in the laboratory. He confirmed that many of the species do in fact have anti-worming properties, and for the majority it was due to tannins. In general, the pods were better at killing worms than the foliage.

From a farm management point of view, this is good news. Sheep will very quickly consume all the foliage within their reach, while the pods fall from the tree at a time of year (mid to late summer) when there can be feed shortages and worm problems.

Between Leon's observations on his farm, the work conducted in the laboratory, and studies from across the globe, it appears wattles might play a useful role as an additional food source and 'drench' for sheep. Ultimately though, controlled field experiments will be necessary to determine the real potential for these plants to play a role in controlling worms.

Wattle trees can produce large quantities of seed pods which can provide an additional source of feed during dry times.

Direct seeding—above, below and beyond

Summaries based on research and honours theses by Bart Schneemann, Zoe Read and Charles Lowson.

In 2008, GA supported three honours students from the Australian National University (ANU) to look at different aspects of direct-seeded revegetation across the Southern Tablelands of NSW. The students examined more than 30 sites to assess how the vegetation and soil compared over the years and across landscapes.

Vegetation composition and structure

In 1998, GA surveyed 78 direct-seeded sites of up to five years old, to determine vegetation composition and structure, namely species, survivorship, densities and growth rates. These surveys were repeated in 2008 on 33 sites and together they span revegetation ranging from 1.5–17.5 years in age.

The results showed the density of the sites declined over time from a maximum of six to a minimum of one-and-a-half stems per metre. Species diversity also declined from 12–16 species to four to eight species per 20 metres. Regeneration was low and altogether only sufficient to replace 13% of live stems in the stands. Regeneration was lowest in older, denser sites which suggests that these are at a stage of stem exclusion or self thinning and are not regenerating. This could be largely due to ongoing drought and lack of a regeneration event.

The implications of this research for WOPR is that ageing stands of trees and shrubs will thin out substantially after a 20-year period returning to a more scattered woodland. If you wish to retain a dense stand, active management such as a grazing spell or a cool burn are needed to encourage regeneration.

Soil carbon, composition and function

This study investigated a range of chemical, physical and biological soil attributes and incorporated landscape function analysis (LFA) to determine changes in soil function within direct-seeded belts and adjoining grasslands.

Results showed that the direct-seeded vegetation compared to grasslands have **higher** (↑):

- ↑ soil organic carbon (SOC)
- ↑ soil surface litter
- ↑ higher total nitrogen
- ↑ A_0 horizon
- ↑ carbon density

They also have **lower** (↓):

- ↓ pH
- ↓ bulk density
- ↓ effective cation exchange capacity
- ↓ total phosphorous concentration

A_0 horizon: That portion of the A horizon of a soil profile which is composed of pure humus.

BHFF: the ratio of a tree's volume to the volume of a specified geometric solid of similar basal diameter and height.

tC/ha: tonnes of carbon per hectare

The LFA results indicate that the direct-seeded belts have improved infiltration, stability and nutrient cycling compared with the grasslands.

The implications for WOPR are the potential to improve soil stability and infiltration, which across large areas can have a significant impact on run off and erosion into adjacent waterways. There was significantly higher SOC in the vegetation belts compared to the grasslands. This remained largely unchanged even in stands which were thinned to create 50% less tree density. This suggests that WOPR can play a key role in creating and maintaining high levels of SOC and also in carbon sequestration.

Above-ground carbon

This project aimed to identify the best carbon measurement model from a selected range, and to estimate the mass of above-ground carbon within direct-seeded vegetation belts. Measurements of tree diameter, height and other characteristics were collected from the vegetation aged between about 12–18 years old on 38 plots. The carbon mass for each plot was estimated using:

i) volume based allometrics that estimate carbon using diameter at breast height (DBH) and tree height measurements

ii) generic allometric relationships that are based on a DBH measurement only

iii) the national Full Carbon Accounting System's (FullCAM) model.

The Full Carbon Accounting Model (FullCAM) is the model used to construct Australia's national greenhouse gas emissions account for the land sector.

A 'best fit' model (BHFF ⅓ allometric) was used to determine carbon in this situation. The above-ground carbon pool — which comprises components of a tree e.g. stem, branches and leaves — was found to contain an average of 24.9 tC/ha. The assumptions within the selected model make this a conservative carbon estimate for these plantings. It is, however, a good baseline estimate of carbon for direct-seeded environmental plantings.

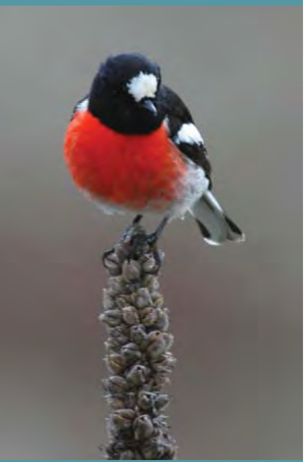
The total above-ground carbon on WOPR sites is likely to be much lower than this estimate of 24.9 tC/ha because:

i) tree cover on a WOPR site is estimated to be only 25–35% of the total paddock area (as opposed to 100% in a dedicated direct-seeded environmental planting)

ii) the impact of long-term grazing is likely to reduce the above-ground carbon.

Measurements taken at the 14-year-old WOPR site in Binalong estimated 3 tC/ha as a reliable, known minimum above-ground carbon figure across the whole paddock. After taking into account a more realistic stem form for trees within the site, however, it was found that the true value is likely to be closer to 3.8 tC/ha.

The study also found that, if the whole paddock was seeded with no break between the vegetation belts, the above-ground carbon mass estimate increases to 11.9 tC/ha. It is also important to remember that this carbon mass estimate covers only one pool of carbon within this ecosystem. Three other carbon pools (including root, litter and soil carbon) have not been included in this study and may substantially contribute to the total carbon sequestered within WOPR sites.



Red-capped Robin.

WOPR—a bird's eye view

Based on research and publications by Nicki Taws and Suzi Bond

Does revegetation provide habitat for native birds? To help answer this, GA teamed up with the Canberra Ornithologists Group and CSIRO in 2000 to undertake the Birdwatch project. Thanks to an enormous effort by volunteers, nearly 400 surveys were undertaken on 133 sites in a region extending from Boorowa to Braidwood.

The project surveyed sites established by both direct seeding and tubestock and ranging in age from 14 months to 14 years. Seasonal surveys over one year revealed a total of 110 different bird species using the revegetation sites. The most common were small insectivorous birds such as the Superb Fairy-wren, Grey Fantail, Silvereye and up to five different species of Thornbill. Particularly exciting was the recording of 15 species of declining woodland birds such as the Speckled Warbler, Red-capped Robin, Diamond Firetail and Southern Whiteface.

Superb Fairy-wren.

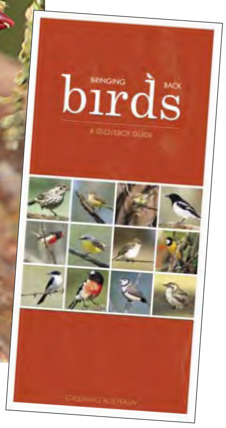
Diamond Firetail, photo Geoffrey Dabb.

Analysis of vegetation at the sites found that more bird species were recorded in older revegetated sites, and those sites that were larger and block-shaped rather than linear. Sites with a greater structural variation in the height and density of the trees, shrubs and ground layer recorded more bird species. A 2003 study found more than 40 bird species breeding in the revegetated sites, 18 of these were woodland birds, including four declining and two threatened species.

In a typical WOPR site you would expect to find between 20–30 different species of birds at any one time. Many of these birds are small insectivorous species that perform important pest control services around the farm. Healthy bird communities remove half to two-thirds of leaf-eating insects within tree patches, thereby keeping vital vegetation growing on farms.

Surveys at all 133 Birdwatch sites are ongoing and the information collected over the last 13 years forms an incredible record of the immense value of revegetation on farms to birds in the wider ACT region. By tracking changes in the bird community as the vegetation structure changes over the years, the 'tall shrub' layer (4–8 metres high) has been identified as the major influence on increasing the number of bird species in revegetation areas.

The survey results led to the production of *Bringing birds back: A glovebox guide for bird identification and habitat restoration.* The booklet features photos and descriptions of the 30 most common birds in this region, 20 species to watch out for, and tips and techniques for revegetating to maximise habitat for birds.



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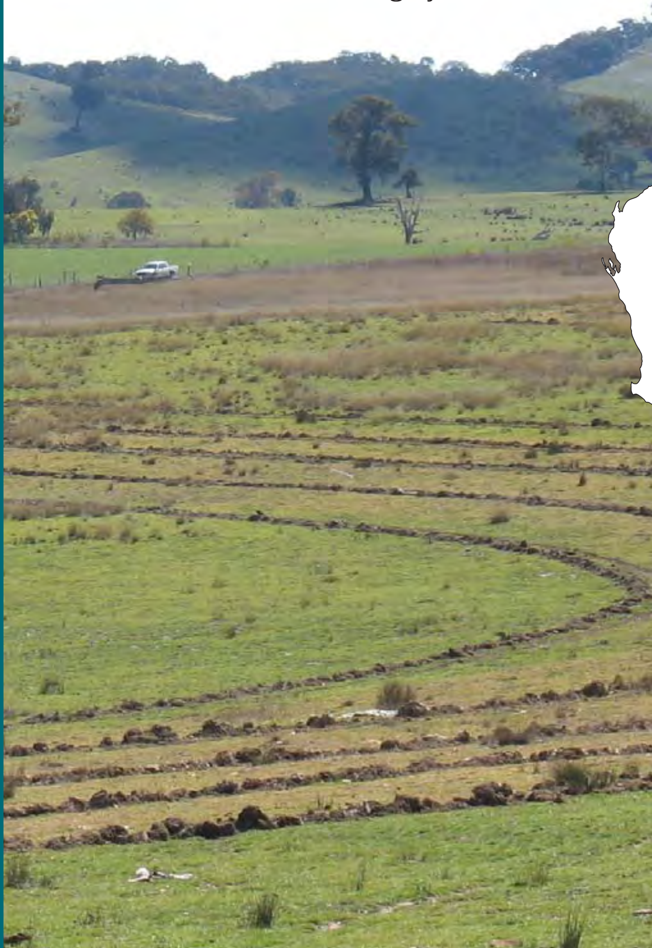

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For electronic copies of the WOPR brochure and selected references go to: www.greeningaustralia.org.au/community/capital-region

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