Enhancing biodiversity

The importance of biodiversity and ecosystem services in production landscapes

Ways to build resilience and stability into vineyard agroecosystems

Mary Retallack, from Retallack Viticulture**,** discusses the importance of optimal biodiversity and the role it plays in creating greater resilience and stability in production landscapes. This is the first in a series of articles that will provide practical insights for growers.

Introduction

Biodiversity refers to the variety of plants, animals and micro-organisms that live and interact within an ecosystem. The organisms within a system perform a myriad of valuable ecological services. In production landscapes this may include tasks that benefit vineyards themselves. For example, by providing a source of predators for pest control, buffering weather conditions such as extremes in wind and temperature, supporting the recycling of nutrients, regulation of hydrological processes including aquifer recharge, minimising soil erosion, and detoxification of chemicals that may otherwise build up within a system (Altieri 1999, Viers, *et al.* 2013). If these natural processes are lost the economic and environmental costs may be significant (Meehan *et al.* 2011). A simplistic ecological network with fewer connections will invariably lead to instability within a production system and require constant human intervention to maintain function.

As a result there has been a shift away from managing vineyards where there is a sole focus on crop production to a more integrated and ecologically sensitive approach. There has been increasing interest and a desire to grow winegrapes as sustainably and efficiently as possible. Growers are entirely dependent on the natural resources available and are increasingly called upon to demonstrate

their environmental stewardship credentials to customers.

In this article we will discuss the importance of biodiversity and how this relates to functional ecosystem services and the importance of building resilience and stability into production landscapes. These insights will assist growers to identify ways they can enhance biodiversity, support the role of ecosystem services, intervene less and create longer-term benefits.

Why is biodiversity important?

Resilience and stability

The intensification of crop production into larger monocultures with little natural habitat or diversity, often results in an increase in pest pressure and a need for greater use of insecticides to combat outbreaks of pests (Meehan *et al.* 2011). This is not surprising. Eminent entomologist Dr. Carl Huffaker, from the University of California, once said, "When we kill off the natural enemies of a pest, we inherit their work." Increasing intensification may become a self-defeating circle where the risk of failure is high. More and more intervention and artificial inputs are required to keep a vineyard productive over the long term. In agricultural landscapes, insecticide use often increases with an increase in the size of a production area and decreases with the proportion of semi-natural habitat present (Meehan *et al.* 2011).

The resilience of a system describes its capacity to maintain balance in response to impacts or pressures that may arise from natural or human impacts. A resilient system is often able to absorb disturbances and 'bounce back' sooner. In this regard, it is generally accepted that if greater diversity is present, it is less likely that individual weed or pest species will dominate, and a farming system will be better able to recover from disruptions, including extreme weather events (Yachi and Loreau 1999). By adopting optimised management practices and promoting the richness of the natural enemies present, they can reduce the density of a widespread group of herbivorous pests, and this may lead to increased yield (Cardinale *et al.* 2003).

It has also been recognised by scientists and ecologists when native vegetation is reduced, natural processes start to break down and fauna species may be lost. By retaining remnant vegetation and revegetating with native species, this will help to support critical natural processes.

Managing a vineyard means managing an agroecosystem (a system on agricultural land) where grapevines are the dominant plant species. But this doesn't mean that it needs to be a monoculture. With an understanding of the importance of a healthy ecosystem, it is possible to enhance biodiversity in production landscapes and develop more complex networks with greater connections. Sustainable land and water conservation along with ecologically compatible vineyard management practices can be employed to ensure vineyards coexist in the landscape and contribute to the enhancement of biodiversity.

An ecosystem is defined as a biological community of interacting organisms and their physical environment interacting together as a functional unit. Historically, humans have modified natural ecosystems to exploit species that yield direct benefits, often overlooking the unseen but essential ecosystem services that if lost are expensive and sometimes impossible to replace (Close *et al.* 2009).

Like all complex systems, ecosystems can appear to be working well until a point when they suddenly collapse. The role of biodiversity in maintaining essential services in human modified landscapes is often poorly understood. For example, small patches of native vegetation such as remnants or roadside vegetation may provide important refuges for a range of species and act as stepping stones to larger inter-connected patches.

Biodiversity

Biodiversity, or 'biological diversity', is the variety of all living things including variety among genes, species and functional traits. It is often measured as richness, or the number of unique life forms present (Cardinale *et al.* 2003). In a nutshell, a system high in biodiversity tends to be more resilient against change. The more complex the system is, the better buffered it is likely to be and the more able to adapt to a change in its dynamics. There is a consensus among ecologists on four key points that sum up the significance of biodiversity loss and its impact on humanity (Cardinale *et al.* 2012):

- change within an ecosystem accelerates as biodiversity loss increases

Figure 1. An example of a fragmented production area with lower native vegetation cover (left) and a less fragmented region with higher native vegetation cover. Photos: Google Earth

- conversely, diverse communities are more productive
- there is unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biological essential resources, produce biomass, decompose and recycle biologically essential nutrients, also known as ecosystem services
- as biodiversity increases, so do the stability of ecosystem functions through time.

It is widely regarded that biodiversity is the engine room of ecosystem services.

Ecosystem services

Ecosystem services are the suite of benefits provided to humans through the transformation of resources into a flow of essential goods and services in an ecosystem. They are often classified into four categories: provisioning, regulating, cultural, and supporting services (Close *et al.* 2009, Mace *et al.* 2012, Schellhorn *et al.* 2015).

1. Provisioning services are the goods or products obtained from ecosystems such as food, fresh water, timber and fiber or, in the case of grapevines, the grapes that are made into wine. Products of ecosystem

services are referred to as 'ecosystem goods'. Provisioning services may also relate to insectary plants that can provide services and goods such as food, shelter and alternative prey to support the presence of predators.

2. Regulating services are the benefits obtained from the control of natural processes such waste decomposition and detoxification, purification of water and air, and biological control of key pests and diseases. A key principle of biological control incorporates the use of native insectary plants. By boosting the presence of beneficial arthropods, they can provide biological pest control or regulating ecosystem services in vineyards for free!
3. Cultural services include non-material benefits such as recreation and aesthetic enjoyment.
4. Supporting services include natural processes such as nutrient cycling, soil formation and crop pollination.

This article focusses on the benefits of provisioning and regulating services.

More on provisioning services

Arthropod 'provisioning' services are derived from insectary plants that provide 'SNAP', an acronym that refers to shelter, nectar, alternative prey and pollen (Barnes *et al.* 2010). These nourish predatory arthropods and extend their presence in production landscapes (Gurr *et al.* 1998). In turn, predatory arthropods provide 'regulating' ecosystem services which involve biological suppression of vineyard pests. Ecosystem services can be enhanced through 'ecological engineering' with native flora (Gurr *et al.* 2004).

Native plants are naturally adapted to dry Australian conditions and are consistently reported as having a low occurrence of pests and high occurrence of natural enemies (Gagic *et al.* 2018). Selected native plants have the potential to deliver high levels of provisioning services that improve the reliability of biological pest control. Plants need to be carefully screened to ensure they do not provide breeding sites for pest arthropod and/or bird species.

More on regulating services

Biological control is an example of a regulating service and is also a key component of arthropod-mediated ecosystem services (AMES), which naturally suppress pests in vineyards (Isaacs *et al.* 2009). When there is a diversity of predatory arthropods, they target different life stages of economically-damaging pests, thereby reinforcing pest suppression (Hogg and Daane 2014). Predatory arthropods that attack pests, such as spiders, brown and green lacewings, ladybird and carabid beetles and predatory bugs, are commonly found in vineyards (Bernard *et al.* 2007, Thomson and Hoffmann 2009).

The majority of predators that attack crop pests are native (Gagic *et al.* 2018), and tend to be found in close association with native plants. If the numbers of predators are low, biocontrol agents from a commercial insect supplier can be purchased and released. Predatory arthropod numbers can then be boosted in the longer-term if suitable insectary resources are present to sustain the populations.

What can growers do to enhance biodiversity?

The agricultural sector plays a primary role in managing large sections of privately held land. Proactive decisions on land use and management have the capacity to positively impact on biodiversity and ecosystem services. For example, stands of native vegetation adjacent to vineyards have been associated with increased biodiversity (Gagic, *et al.* 2018, Smith, *et al.* 2015, Thomson and Hoffmann 2010, Thomson and Penfold 2012) and provide season-long benefits to boost the activity of predators and parasitoids (Thomson and Hoffmann 2013). Existing vegetation structures such as windbreaks, vegetation corridors, mid-row, under-vine and headland plantings that are associated with a vineyard can be enhanced to provide insectary resources (Nicholls, *et al.* 2001, Thomson and Hoffmann 2009, Thomson and Hoffmann 2010) and/or stands of remnant vegetation can be preserved.

Biodiversity as an indicator of vineyard health

Increased biodiversity is often promoted as an important indicator of vineyard health (Altieri 1999, Barnes *et al.* 2010, Bruggisser *et al.* 2010, Gurr *et al.* 2003,

Figure 2. A vineyard with a bare earth policy results in a simplistic network with fewer connections (left) compared with a more complex network, or interconnected vineyard system (right). Photos: Mary Retallack

Thomson and Penfold 2012, Winter *et al.* 2018). However, the measurement of biodiversity is difficult. Thomson *et al.* (2007) suggest that a surrogate indicator such as the diversity of predatory invertebrates, which have a direct impact on pest abundance, can be used as one way to assess the benefits of enhancing biodiversity. As growers consider moving towards an integrated system, it is important to incorporate a diversity of different plant forms. Consider the timing of flowering, a range of different vegetation heights, annual and perennial species, and/or multi-species mix where possible.

Conclusion

Sustainable and productive vineyards can be managed in biodiverse production landscapes that deliver profitability, ensure species and habitat protection, and provide of a full range of ecosystem services in the long term (Viers *et al.* 2013). Winegrowers are encouraged to enhance the biodiversity and resilience of their vineyards by preserving stands of remnant vegetation, reclaiming creek lines that may be infested with exotic woody plants and revegetating adjacent land with native plants derived from local plant community lists. Native plants must be selected that are appropriate for use in and around vineyards. Enhancing biodiversity using native plants in vineyards also adds to our capacity to tell our unique Australian story and demonstrate our green credentials.

Future articles in this series will touch on the role of native insectary plants, their attributes and how to establish them, the diversity of predatory arthropods found in vineyards, and ways to monitor native insectary plants and assess their benefits. For instance, if growers can boost the presence of predatory arthropods, then there are potentially millions of little insect workers that can provide natural biological control of vineyard pests for free! We must continue to enhance our understanding of how to attract and look after them.

Supporting resources

There are a range of resources available if you would like to find out more:

Enhancing biodiversity in the vineyard http://www.viti.com.au/pdf/Enhancing%20Biodiversity%20in%20the%20Vineyard%20-%20Workshop%20Notes.pdf

Vineyard biodiversity and insect interactions: establishing and monitoring insectariums http://www.viti.com.au/pdf/RmjrVineyardBiodiversityandInsectInteractionsBookletFINAL.pdf

PPWPCMA Native Insectaries http://www.ppwcma.vic.gov.au/major-projects/regional-landcare-facilitator/native-insectarium-trial/

Creating Resilient Landscapes in the Barossa https://www.barossa.com/members/barossa-grape-and-wine-association/bgwa-nrm-partnership-projects

McLaren Vale Biodiversity Project https://www.facebook.com/McLaren-Vale-Biodiversity-Project-681026865318172/

Entwine Australia www.awri.com.au/industry_support/entwine

Sustainable Australia Winegrowing (SAW) www.sustainableaustralia.info

Mary Retallack, from Retallack Viticulture, and Dan Falkenberg, Eden Hall Wines, will be presenting at the Australian Biological Farming Conference 2018 in November on the Gold Coast. For more info see *www.australianbiologicalfarmingconference.org*

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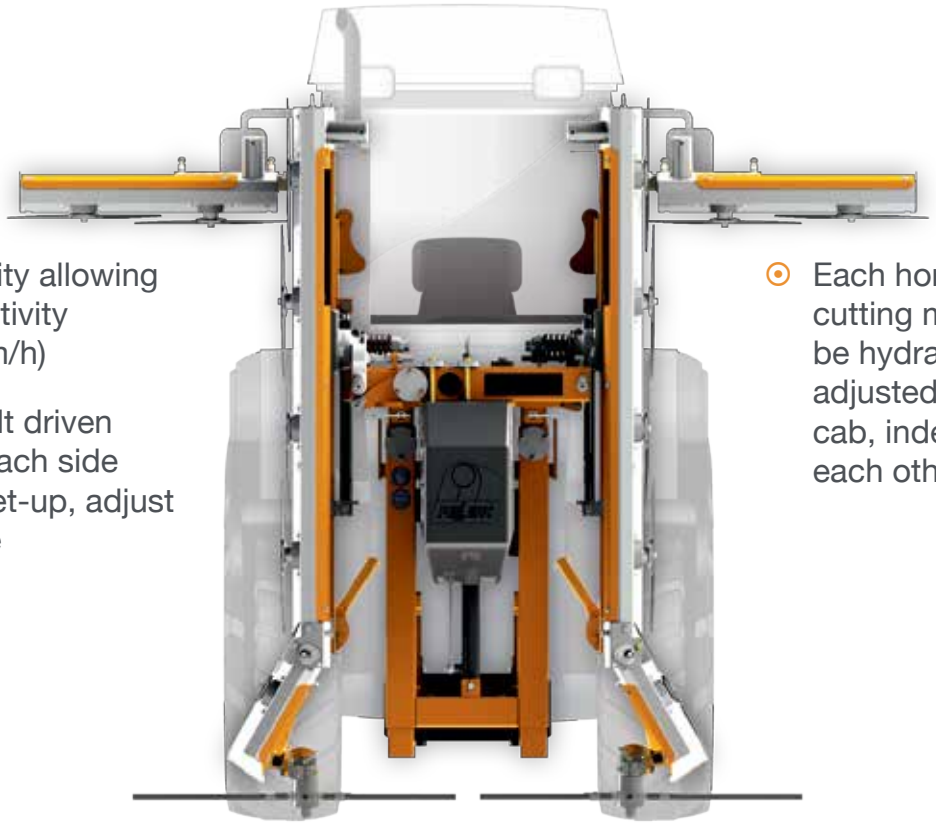

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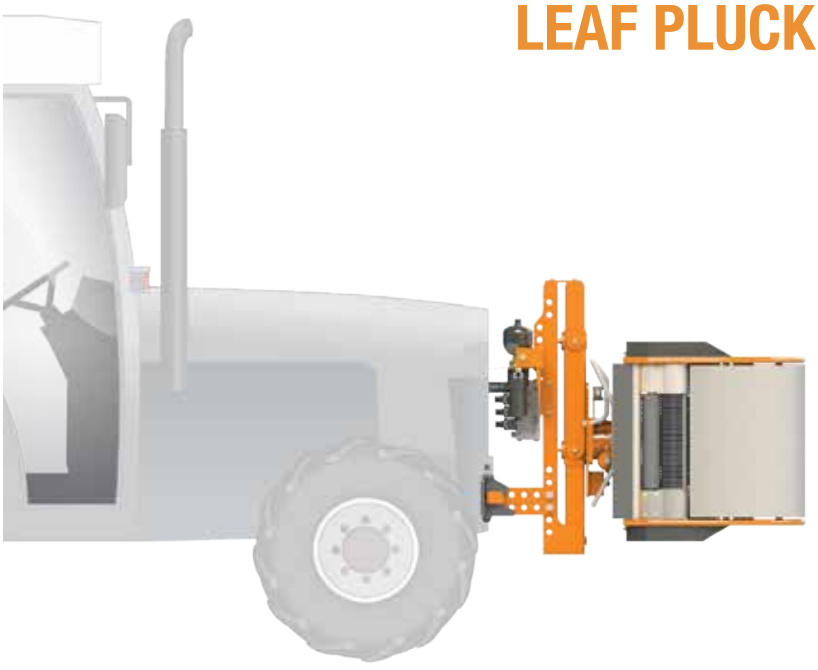

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Figure 3. Grapevines (left) and insectary plants (right) provide provisioning services. Winegrapes from grapevines and nectar and pollen from insectary plants are examples of 'ecosystem goods'. Photos: Mary Retallack

Figure 4. Regulating services are provided by biocontrol agents including predatory arthropods (left) and parasitoid wasps (right). Photos: Mary Retallack (left) and Michael Keller (right)

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