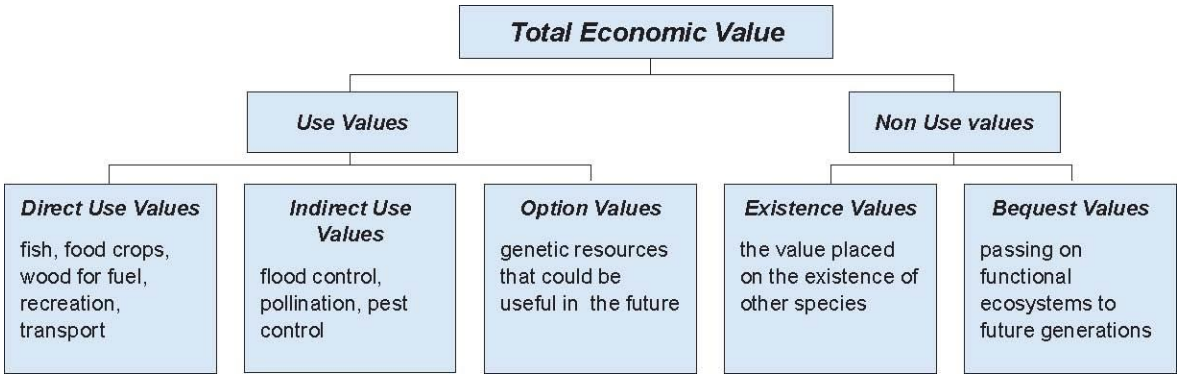
1 Ecosystem Services, Goals and Objectives

We value our environment for the ecosystem services we derive from it. Ecosystem services are a function of land uses. Mining companies and conservationists place differing values on different aspects of the landscape. Farmers value landscape features differently to traditional owners or peri-urban dwellers. The community's goals for NRM are reflective of land use, and are typically associated with preserving the integrity of natural resources, on which they rely for their health and well-being, whilst continuing to derive ecosystem services.

Natural resource management should be viewed within the context of land use and the quality and value of ecosystem services derived from those natural resources. Ecosystem services range from deriving economic returns, food and fibre, fresh water, natural beauty, cultural services, and environmental regulation and conservation to a desire to bequest structurally sound and functional environments to future generations. A schematic of NRM values is illustrated in Figure 1.

Figure 1. Components of NRM Values (from Cork et al. 2000)



1.1 Natural Resources

The underlying natural resources of the ARB include:

- Soil
- Water
- Biota
- Atmosphere
- Minerals.

Although often described as discrete components, natural resources within the region are in fact intertwined into a series of complex and overlapping ecosystems in functional landscapes. Ecosystems are the expression of the entire biophysical system, consisting of all the biota (living organisms) and abiotic (nonliving) resources, including plants and animals, soil, water, minerals, sunlight and the atmosphere. The structure and function of ecosystems within the region are essentially governed by underlying land use.

The socio-ecological system is a combination of the ecosystem and the socio-economic components of the land use applied to those ecosystems in deriving ecosystem services. Understanding the

interactions between an ecosystem and the socio-economic environment is critical in determining the capacity of the community to respond to and manage impacts associated with deriving ecosystem services from natural resources within the region.

1.2 Land use

Ecosystems reflect current and historic land use. Agricultural ecosystems (farmland) contain very different biota, soil characteristics, and water dynamics than do areas of native vegetation, urban, peri-urban or mining environments.

Different land uses require access to different natural resources, and in turn influence surrounding natural resources in different ways (refer Table 1). For instance, agriculture requires access to soil, water and the atmosphere, and affects those resources in ways that have consequences for the environment and the surrounding biota.

Table 1. Land Use and Natural Resources

Land Use	*Soil*	*Water Resources*	*Water for Environment*	*Biota*	*Atmosphere*	*Minerals*
Agriculture	*	*		*	*	
Urban	*	*		*	*	
Peri Urban	*	*		*	*	
Mining		*			*	*
Unallocated Crown Land (UCL)	*				*	
Conservation	*		*	*	*	
Traditional	*	*	*	*	*	*

* *Land use directly uses natural resources*

Land use impacts capacity of natural resources

Consistent with other parts of this strategy review, water is considered as a combination of *water resources* and *water for the environment*. Even though it is all the same water, different land uses seek to utilise water in different ways. Agriculture, urban, peri-urban and mining land uses require access to water resources in deriving ecosystem services. Conservation and traditional land uses also require access to water, but very different indicators are used to determine the effectiveness of ecosystems in providing services demanded by different land uses.

All land use requires access to soil, but agriculture has a specific soil requirement. Agriculture causes soil properties to change from their natural state, resulting in reduced soil water repellence and increased fertility, but can also dramatically reduce soil health, including its structure, biota, pH, cation and anion concentrations, and stability.

Water for the environment is affected by all land uses, and potentially negatively affected by agricultural, peri-urban, urban and mining uses. Conversely, conservation and traditional land use require access to uncontaminated water for healthy ecosystem function.

Whilst agriculture and urban environments typically do not derive ecosystem services directly from the natural biota, there is little doubt that maintaining healthy ecosystems is essential to maintaining healthy agricultural and urban environments. Urban, peri-urban and agricultural environments need biota to derive a sense of place and recreational values from the natural environment. The biotic environment provides a range of ecosystem regulation services including pest management, shelter, and contaminant filtration, whilst presenting challenges including those associated with vermin control.

Mining requires access to minerals and water resources for operation and processing, thereby influencing water for the environment, biota, land and the atmosphere.

All land uses require access to the atmosphere, with agriculture and biota entirely reliant on its capacity to deliver sufficient rainfall to maintain the current structure and function of associated ecosystems. Evidence indicates that agriculture may influence regional atmospheric conditions; the climate of the ARB has already been adversely impacted through the combination of various external stressors that may include the impacts of region deforestation (McAlpine et al 2008).

Traditional land use requires access to all natural resources. In its historic context, traditional land management in Australia involved active management of the ecosystem in deriving a range of ecosystem services. .

1.3 Ecosystem Services

Heterogeneous communities are unlikely to have entirely shared values and objectives and this should be reflected in associated management strategies. It is important to understand that the expectations of the broader community may be difficult to meet, particularly where the bulk of the investment in managing natural resources is derived from the local community.

Different sectors of the community derive different ecosystem services from natural resources and may hold distinctly different underlying values relating to natural resources and objectives for managing them. The heterogeneous community of the Avon region is a reflection of its variety of land uses. Land use is the key factor influencing the structure and function of ecosystems and in turn stressors on natural resources. In determining strategies for engaging the community in more effective NRM, it is important to consider the relationship between land use and the ecosystem services derived from the underlying natural resources.

Ecosystem services range from the production of food and fibre and other commodities to cycling of nutrients and climate regulation, to flood regulations and disease protection, to social cohesion, a sense of place, cultural and spiritual connection and a general sense of well-being. The various ecosystem service demands of the range of land uses within the ARB are presented in Table 2.

Table 2. Land use and the Derived Ecosystem Services

	Land use						
Ecosystem Services	*Agriculture*	*Urban*	*Peri-Urban*	*Mining*	*UCL*	*Conservation*	*Traditional*
Food & Fibre	*		*				*
Mineral Resources				*	*		
Recreation / Tourism		*			*	*	*
Sense of Place / well-being	*	*	*		*	*	*
Climate regulation	*				*	*	
Conservation of Genetic Resources					*	*	*
Water Resources	*	*	*	*			
Water Quality - Water for environment			*		*	*	*
Indigenous Cultural Heritage Values					*	*	*
European heritage values	*	*					

* *Land use derives service*

Land use impacts capacity of natural resources to deliver ecosystem services

1.4 Goals and Objectives

The previous Avon Regional NRM strategy (ACC 2005) stated goals and objectives for the individual resource condition, but these were entirely aspirational and there was no virtually no capacity to reach the stated objectives.

It is contended that a shared vision is essential to achieve meaningful and on-going positive NRM outcomes within the region, but goals for individual issues may serve little purpose (Wallace 2011, Duane 1997). Table 2 highlights that the ecosystem services and therefore the underlying goals and objectives of the community are a reflection of the associated land uses.

Agriculture is the predominant land use within the ARB; it impacts a range of ecosystem services important to other land uses, including the capacity of the ecosystem to effectively deliver these services by affecting soil health, water resources and regional climate, resulting in direct and indirect feedback to land management practice. Engaging the agricultural community in broader NRM goals will require a focus on the values associated with ecosystem services. In achieving environmental outcomes, it will be important to focus on the appropriate ecosystem services, including a sense of place, climate control and recreational services derived from natural ecosystems within the region.

Engaging the mining sector in sharing visions for environmental management may be more difficult, as the ecosystems services derived by the mining industry are very specific (minerals and water resources). Nevertheless, the mining sector potentially has pervasive impacts on a range of ecosystem services. As a result, environmental management within the mining sector requires strong legislation and the industry is accordingly highly regulated. It is also likely that outside of a desire to be good corporate citizens, there is little direct motivation for the mining sector to actively engage in a shared vision for a healthy and vibrant environment.

Urban land use requires access to water resources, recreation and a sense of place; urbanisation impacts water for the environment through stormwater discharge and conservation through clearing of native vegetation and introduction of environmental weeds. Engaging urban and peri-urban communities in environmental management should focus on the common ecosystem services derived from the environment, such as a sense of place, recreation and water for the environment. An example is highlighting local impacts on the aesthetic value of the environment resulting from water quality degradation.

Ecosystem services derived from traditional land use are many and varied. It is considered that traditional land use is relatively benign for the most part, typically not significantly influencing the capacity of the region to deliver the range of desired ecosystem services. However, historically traditional land use shaped the environment profoundly, particularly the biotic components of natural resources, through the use of fire.

Setting specific goals for individual resource condition within the region presents potential difficulties. The development of aspirational goals for individual resources does not necessarily assist in making informed decisions about the most effective investment, which is the primary purpose of the Wheatbelt NRM strategy.

The concept of stating specific goals for individual resource conditions raises two key issues:

- *Goals should be stated in the context of the likely investment to ensure that they are meaningful and achievable rather than purely aspirational*
- *An honest appraisal of the likely outcome of projected investment may not be palatable to either the community or government, and little information is available to make a realistic appraisal of the potential impact of resource condition.*

The role of the Wheatbelt NRM strategy is to set broad priorities and establish a framework for informing investment within the region. It should be noted that the strategy will be used by other organisations (Wheatbelt Development Commission, LGAs, government agencies, NGOs), who – whilst have an interest in NRM – may have vastly different priorities.

A range of potential goals for managing resource condition are recommended in this report. Specific goals are intended to be included in annually updated investment plans to take new information into account and to assess the likely investment streams and barriers to achieving outcomes.

Resource condition targets fit into a range of potential management frameworks:

- *Resource recovery (where it is feasible to overcome resource condition impacts, such as soil acidity and soil water repellence)*
- *Maintain current resource condition by limiting future degradation (for conditions that appear to have stabilised, such as salinity and nutrient loads in the Avon River)*
- *Slow the rate of resource degradation (where the actual process is out of our control, land salinity for instance, where investment is unlikely to arrest the underlying cause of the problem)*
- *Manage the impacts of emerging stressors. (Managing the predicted impact of external stressors – for example, response to predicted climate change)*
- *Reduce final extent of change in resource condition (where the underlying stressors are so pervasive that we are unable to manage them, but we have the capacity to influence the overall impact. This is most relevant to biodiversity and aquatic health outcomes for the region)*
- *Adapt to the alternate state (in cases where there is no or very limited capacity to overcome the stressor – for instance, revegetation of saline land with saltland pastures, and impacts of climate change on water resources and environmental flows).*

1.5 Land Use Impacts

Resource condition impacts are a direct result of the land use through which the community and industry derive ecosystem services from our environment. Land use (or more specifically, land use practice) is in turn impacted by external factors or stressors such as climate, world economic trends, and government regulation and policy. Land use is also impacted by feedback loops associated with deriving ecosystem services and impacts to natural resources, as outlined in Figure 2.

Figure 2. Feedback Loops Impacting Land Use

Under-valuing ecosystem services typically leads to patterns of unsustainable resource use and a range of degradation processes including species extinction, pollution of waterways and declining soil health, resulting in economic and social welfare impacts. Maintaining long-term, intergenerational values (such as existence and bequest values) can only be achieved if the full environmental cost of providing valued ecosystem services is met.

A range of impacts associated with ecosystem services are derived through the variety of land uses within the region. In industries where it is difficult or impossible to set sustainable prices (such as agriculture) or where the profits are purely associated with exploitation of resources and are not reliant on sustainable and resilient ecosystem management (such as mining), degradation of natural resources may be inevitable.

Effective NRM needs to consider the value of ecosystem services derived from various land uses, the impact of land use on natural resources and the associated feedback to better assess the motivation and aspiration of land managers. Feedback loops are important in governing land use practice and therefore in NRM. For instance, if climatic and world economic pressures result in poor yields landholders will be forced to change management practice, particularly where yields fall below the break-even point.

Indicators can be used to determine if ecosystem service demands are being met and to assess the impact on the underlying resource base. A thematic assessment of the linkages between external stressors, land use practice and resource impacts (left hand side of Figure 2), including indicators and thresholds, is presented in Figure 3–Figure 6.

The quality of ecosystem service derived from natural resources within the region is more difficult to assess, principally due to the qualitative nature of the many of the services derived. Nevertheless, preliminary indicators and associated thresholds are presented in Table 3.

Table 3. Indicators and thresholds for key ecosystem services.

Ecosystem Service	***Indicator / surrogate***	***Threshold***
Food & Fibre	*Wheat yield* *Regional Grain production*	*1.6 t/ha* *12 Mt*
***Economic** well-being*	*Debt: income ratio* *Regional GDP*	*3:1* *$6 billion*
Mineral Resources	*Growth in mineral industry*	
Recreation / Tourism	*Visitor numbers to parks*	
Sense of place / well-being	*Population trends*	*Population growth > 0* *Town size 500 residents*
Climate regulation	*Winter rainfall*	*Year 2000 trend*
Conservation of Genetic Resources	*Species loss*	
Water Resources	*Dam reliability*	*95%*
Water Quality - Water for environment	*Nutrients, salinity*	*TP 0.1 mg/L* *TN 1.0 mg/L* *Salinity 10,000 mg/L*
Indigenous Cultural Heritage Values	*Indigenous participation*	
European heritage values		

1.6 References

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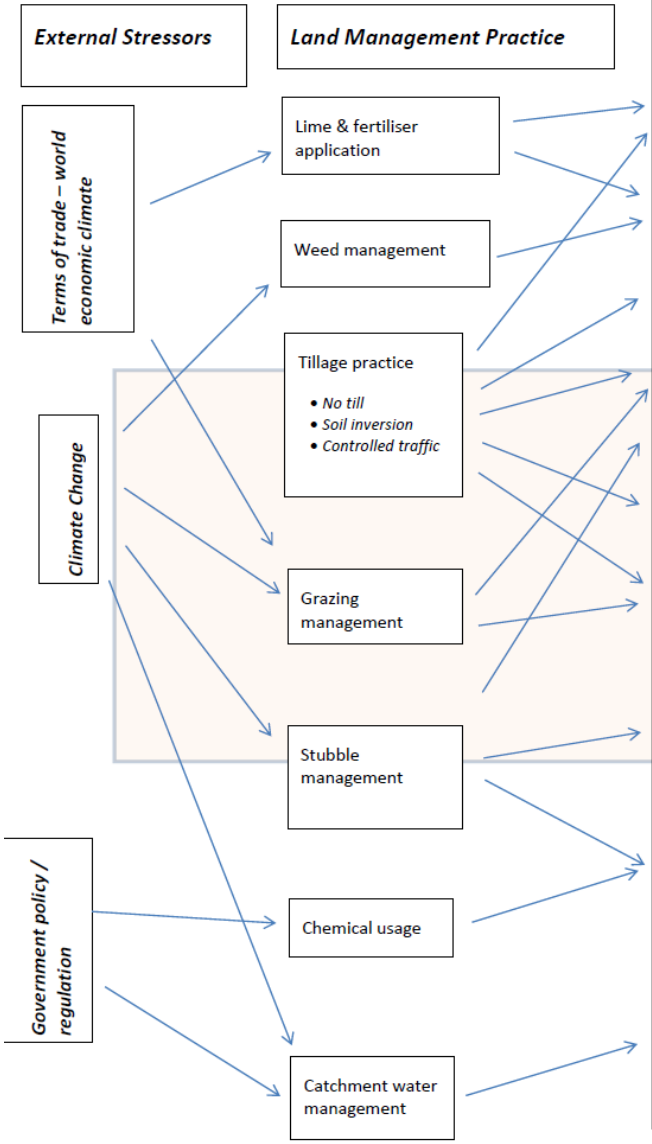
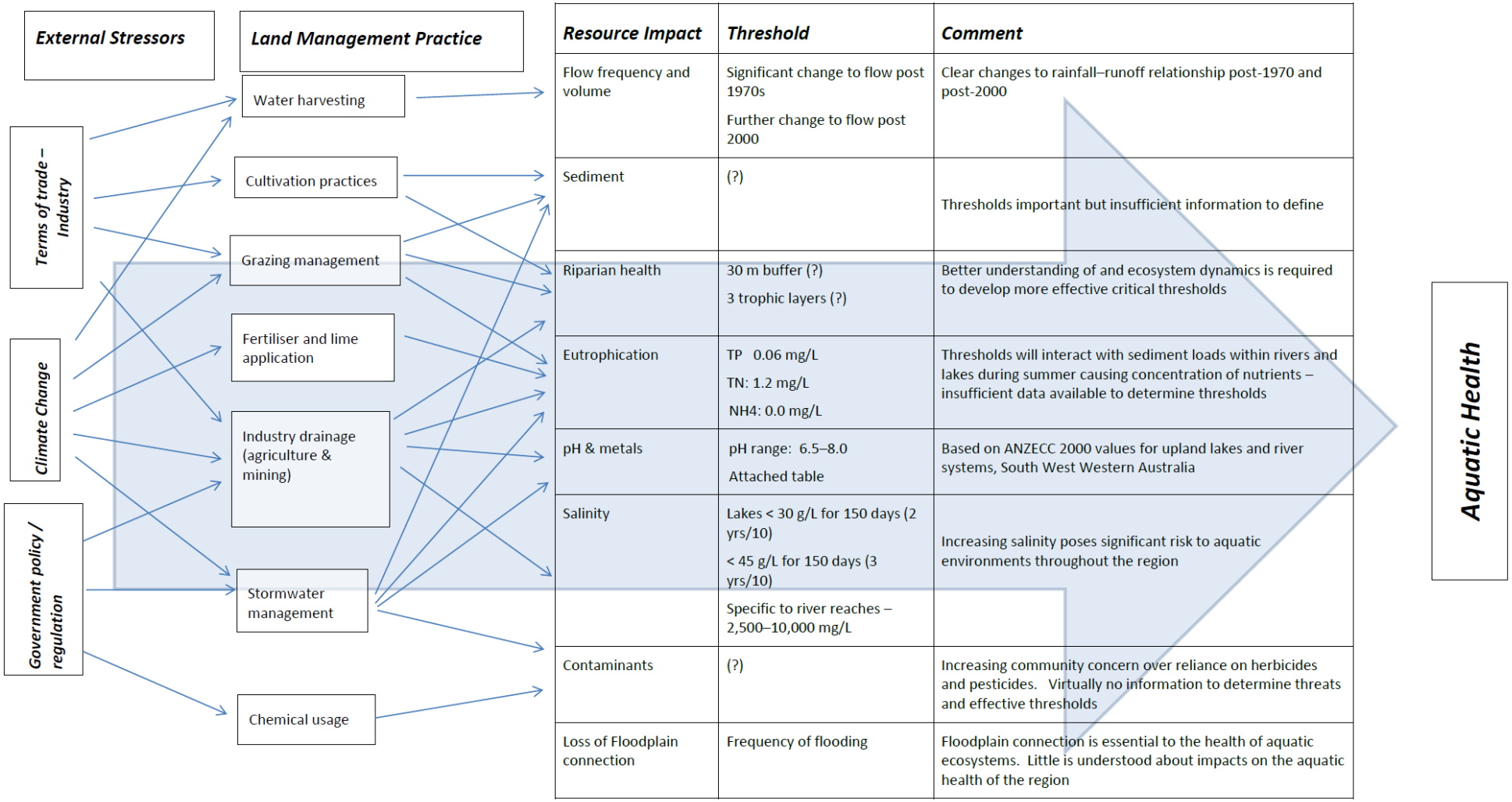


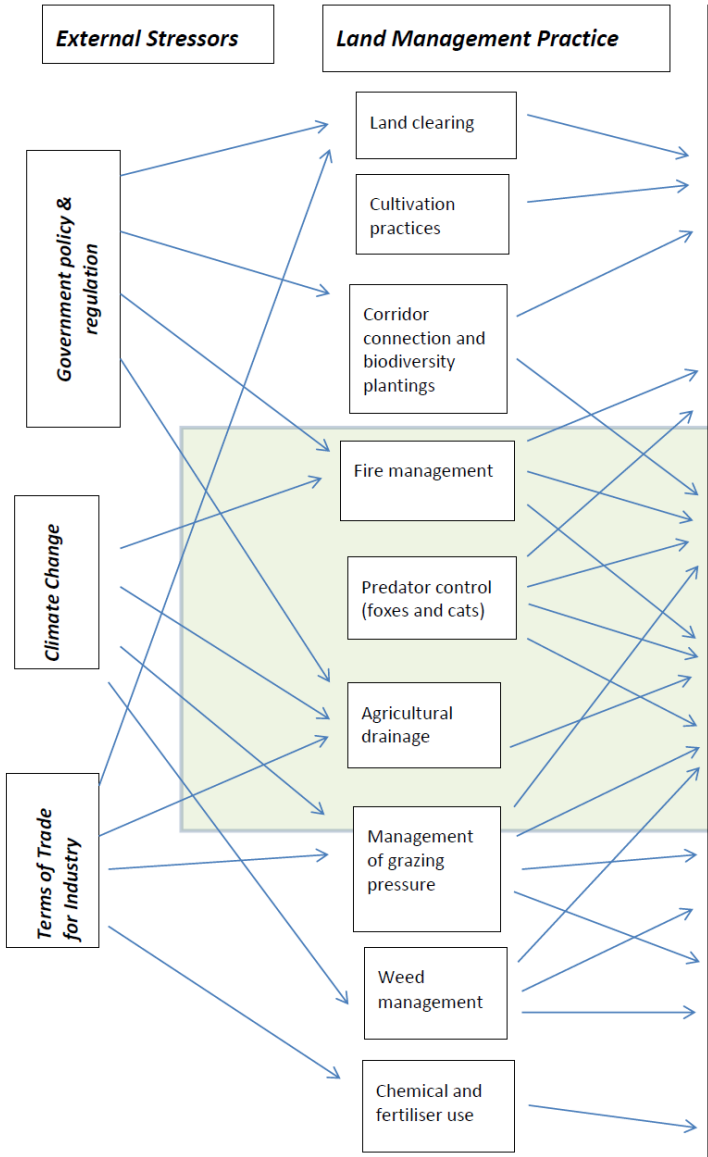
Resource Impact	Threshold	Comment
Soil Acidity	Topsoil: 5.5 (CaCl) Subsoil: 4.8 (CaCl)	Currently 80% of the ARB has soil salinity of < 5.5 (CaCl) and 50% of sub soil < 4.8 (CaCl) Rate of increase not well defined
Nutrition		50% of soils limited in nutrients other than P Limits to production often not known by landholders – improve soil testing
Compaction	Penetrometer resistance 2Mpa	Agronomic response
Soil structure decline	ESP: 6 CEC: Ca 1.5, Mg 0.4, K 0.3, Na 0, Al 0	Response to no-till well documented. Links to SOC important Potential increase in grazing potential stressor for soil structure
Repellance		Periodic soil inversion being trialled with grower groups as management practice
Erosion	Paddock cover 50%	Influenced by roughness, soil types, remnant windbreaks, pasture & stubble etc. Reduced contour farming due to adoption of controlled traffic potential stressor on soil erosion
Soil organic carbon	2.5% (?)	Soil organic carbon is often not a good indicator for assessing soil qualities Potential for increased carbon storage within soils
Soil biota		Indicators and thresholds no easily defined Potential impact of chemical use on soil biota not well understood Motivator for many landholders
Salinity	Non-saline: < 2dS/m (ECe) Mildly saline: 2–8dS/m (ECe) Highly saline: > 8 dS/m (ECe) Groundwater within 2m of natural surface Catchment salinity (10–20%)	Potential impact of climate change not well understood Current area of salinity and rate of spread not known Extent of salinity at equilibrium not well understood Highly motivating for many landholders 50% of landholder impacted (6% of land surface)

Soil Health

Figure 4. Land Management Practice Resource Impacts and Thresholds for Aquatic Health



Resource Impact	Threshold	Comment
Flow frequency and volume	Significant change to flow post 1970s Further change to flow post 2000	Clear changes to rainfall–runoff relationship post-1970 and post-2000
Sediment	(?)	Thresholds important but insufficient information to define
Riparian health	30 m buffer (?) 3 trophic layers (?)	Better understanding of and ecosystem dynamics is required to develop more effective critical thresholds
Eutrophication	TP 0.06 mg/L TN: 1.2 mg/L NH4: 0.0 mg/L	Thresholds will interact with sediment loads within rivers and lakes during summer causing concentration of nutrients – insufficient data available to determine thresholds
pH & metals	pH range: 6.5–8.0 Attached table	Based on ANZECC 2000 values for upland lakes and river systems, South West Western Australia
Salinity	Lakes < 30 g/L for 150 days (2 yrs/10) < 45 g/L for 150 days (3 yrs/10) Specific to river reaches – 2,500–10,000 mg/L	Increasing salinity poses significant risk to aquatic environments throughout the region
Contaminants	(?)	Increasing community concern over reliance on herbicides and pesticides. Virtually no information to determine threats and effective thresholds
Loss of Floodplain connection	Frequency of flooding	Floodplain connection is essential to the health of aquatic ecosystems. Little is understood about impacts on the aquatic health of the region



Resource Impact	Threshold	Comment
Habitat loss / restoration (fragmentation)	Landscape scale: 30% remnant Local scale: 10 ha & 100 ha Corridor width: 30 m (?) Remnant vegetation buffers: 30m	Clearing principally associated with change of land use and mining operations Loss of paddock trees through broad-scale adoption of controlled traffic Size and composition requirements of habitat restoration plantings to achieve minimum biodiversity standards largely unknown
Loss of vigour & species loss	Vegetation index Keystone species	Potential use of "veg machine" to track vegetation vigour Poor understanding of keystone species
Senescence of shrubland heath and associated communities	20–30 year fire interval Critical natural grazing pressure Effective predator control	Cause of senescence well documented, however limited operational experience in management Better understanding the interaction of fire management and grazing impacts required
Decline of woodland health	30–50 year fire interval Critical effective weed control	Woodlands appear to be the ecosystem most threatened by climate change Fire management for woodlands particularly within the Great Western Woodland not well understood Extent of future salinity treat unclear
Decline / management of mallee health	20–50 year fire interval	Relatively poor understanding of mallee vegetation management criteria
Lack of recuitment & sellective removal of species	Remnant is fenced to allow effective grazing management	Weed control in fenced remnants typically required to allow regeneration
Chemical and nutrient contamnation of remnants	(?)	Impacts of herbicides and pesticides not well understood

Ecosystem Health

Figure 6. Land Management Practice resource impacts and thresholds for Community Health