3. LAND CAPABILITY ASSESSMENT

Land capability assessment, as used in Western Australia is similar to stage two suitability assessment described in FAO (1976, 1983). The term 'land resource suitability' has recently become the adopted national standard. Because of the prevailing use of the term land capability in WA, we continue to use it here.

Land capability refers to the ability of land to support a type of land use without causing damage (Austin and Cocks 1978). It thus considers both the specific requirements of the land use, e.g. rooting depth or soil water availability, plus the risks of degradation associated with the land use, e.g. phosphorus export hazard or wind erosion. Five land capability classes are used (Table 3).

Table 3. Land capability classes for given land use types (adapted from Wells and King 1989)

Capability class	General description
1 Very high	Very few physical limitations present and easily overcome. Risk of land degradation is negligible[18].
2 High	Minor physical limitations affecting either productive land use and/or risk of degradation. Limitations overcome by careful planning.
3 Fair	Moderate physical limitations significantly affecting productive land use and/or risk of degradation. Careful planning and conservation measures required[19].
4 Low	High degree of physical limitation not easily overcome by standard development techniques and/or resulting in high risk of degradation. Extensive conservation measures and careful ongoing management required.
5 Very low	Severe limitations. Use is usually prohibitive in terms of development costs or the associated risk of degradation.

A good way to consider capability ratings is to imagine that you are looking to purchase some land to conduct a particular land use. Given that other factors such as price and location were suitable, your first choice would be land was rated capability classes 1 or 2.

Class 3 land would still be worth purchasing for the use, especially if suitable class 1 or 2 land was not available. You might even consider buying this land in preference to class 1 or 2 land if it was considerably cheaper to purchase, had better water supplies or was located in close proximity to your market[20]. However you should give careful consideration to the extra costs or management required to overcome its physical limitations. You may also have to weigh up the potential for lower returns if this land was not as productive as class 1 or 2 land.

You generally would not consider purchasing class 4 or 5 land for the proposed use. In the long term, the costs involved in managing this land in a sustainable manner are unlikely to be offset by the returns from your enterprise.

Of course most properties will consist of land of with a range of capability classes. What you would be looking for is something with large enough area of land that is rated class 1 and 2 for the proposed use with the balance being class 3. Alternative uses could be considered for the class 4 and 5 land.

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[18] Experience has shown that very few land use developments have no negative effect on land degradation, hence capability class 1 will not occur for most land uses employing conventional management and development techniques.

[19] Class 3 is often the largest category of land. It can be highly productive agricultural land which requires the adoption of certain land management practices to minimise the risk of degradation (e.g. the establishment of wind breaks to reduce wind erosion). In other cases Class 3 land could be lower productivity than Class 2 land.

[20] When using a general rating for annual horticulture, class 3 land might be preferred to class 1 or 2 for a specific crop e.g. for summer-grown melons waterlogging is less restrictive.

3.1 Land capability ratings tables

The land capability ratings tables are the standard assessment adopted by the Department of Agriculture in WA for interpreting land resource mapping. They provide land capability ratings for each zone land unit (Section 1.5) by matching land use requirements with the land quality values (Section 2) assigned to that zone land unit. Each of the 22 land qualities has potential to affect the successful implementation of a particular land use, though it will not necessarily be relevant to every land use.

Land capability ratings tables are presented for the following land uses:

- Grazing
- Cropping
- Perennial horticulture
- Annual horticulture
- Septic tanks for rural residential developments (used in combination with other land capability classes to assess capability for specific rural residential developments).

These land capability ratings tables update those described by Wells and King (1989) and van Gool and Moore (1999). There is also a brief consideration of urban land capability.

In the tables, each value of the relevant land qualities is assigned a rating from 1 to 5 as shown in Table 3. The overall capability rating is determined by the most limiting factor or factors (i.e. the quality or qualities assigned the highest number).

The rating does not change according to how many most limiting factors there are. For example there is no difference in the overall rating for a zone land unit with a class 4 rating due only to waterlogging compared with another land unit where class 4 is due to waterlogging, salinity, flooding and water erosion hazard.

Most of the ratings tables are based on broad (generalised) land uses that reflect common current management practices. When using a land capability rating it is essential to be aware of the land use definition which takes into account assumed management practices of the use. A change in the land use definition will often lead to a change in the capability rating. For example, cultivation practices impact on the erosion hazards in dryland cropping, and some land will have a different rating for cropping with minimum tillage as opposed to traditional tillage.

Below each table is a description of how each land quality affects the land use and what management techniques can be employed to overcome the limitation.

Land capability subscripts

Wells and King (1989) identified codes for land qualities which could be used as a subscript when capability classes were recorded. For example land with a capability rating of "**5iy"** for perennial horticulture has very low capability due to waterlogging/inundation risk (i) and salinity hazard (y). Land qualities that are essentially the same as those described by Wells and King (1989) use identical subscript codes. New land qualities are prefixed by a "*z*" (e.g. *za* is water repellence susceptibility).

These optional land quality subscript codes are given in Table 2, and in the land capability ratings tables. Land capability subscripts may be useful for presenting large tables of information. Land quality subscripts are not currently produced routinely because there is no method for determining them developed within the map unit database as yet, and there has been little demand. Instead important qualities are usually presented as a separate thematic map and reported independently, for example on a map showing all areas subject to high waterlogging/inundation risk.

3.2 Land capability for annual horticulture

The assessment for annual horticulture covers the production of irrigated horticultural crops from plants with short-term life cycles (typically completed within the period of a year). Crops include annual fruits (strawberries, melons, etc.), vegetables (e.g. potatoes, lettuce, cabbages, tomatoes, pumpkins, etc.), commercial turf production and cut flowers.

The assumptions for the land use as assessed include:

- crops are grown for commercial production
- crops are shallow-rooted with most roots using only the top 50 cm of soil
- crops are irrigated using sprinkler or trickle systems
- mechanised cultivation occurs at least annually
- fertilisers and herbicides, fungicides and/or pesticides are broadcast at least annually
- crop rotation is practised
- considers physical requirements only and ignores socio-economic factors.

In this assessment preference is given to land suitable for year-round cropping and which would be able to support a wide variety of crops. Class 1 or 2 land has the greatest versatility, there being few production or environmental limitations for a wide range of crops. Capability class 3 has moderate to high limitations for some or all crops. Some class 3 land may have a high capability for individual crops that can tolerate a wide range of soil conditions, but be unsuited to other crops. Land well suited to summer cropping but suffering from winter waterlogging would also be rated as class 3.

Class 4 and 5 land will be unsuitable for commercial production of most crops, although there may be some individual crops with specific requirements and tolerance that can be grown on this land. For specific crops or summer cropping, a separate ratings table should be used.

It should be remembered that the ratings derived from these tables relate to the suitability of the land resource only. They do not take into account factors such as the availability and quality of water supplies for irrigation or climatic risks such as frost or heat stress. Such factors need to be considered as a separate layer of information.

Table 3.2. Land capability ratings for annual horticulture

Land quality and (capability subscript)	Land capability class				
	1	2	3	4	5
Flood hazard *(f)*	N	L	M		H
Land instability *(c)*	N, VL, L		M	H	
pH 0-10 cm *(zf)*	Slac, N	Mac	Vsac, Sac, Malk, Salk		
pH 50-80 cm *(zg)*	Slac, N	Mac	Vsac, Sac, Malk, Salk		
Phosphorus export *(n)*	L	M	H	VH	E
Rooting depth *(r)*	D, VD	M	MS	S	VS
Salinity hazard *(y)*	NR		PR	MR, HR	PS
Salt spray exposure *(zi)*	N			S	
Surface salinity *(ze)*	N		S	M	H, E
Site drainage potential *(zh)*	R, W, MW	M	P		VP
Soil water storage *(m)*	M, H, ML	L	VL		
Soil workability *(k)*	G	F		P	VP
Trafficability *(zk)*	G	F	P	VP	
Water erosion *(e)*	VL	L	M	H, VH	E
Water repellence *(za)*	N, L, M	H			
Waterlogging *(i)*	N, VL	L	M	H	VH
Wind erosion *(w)*	L	M	H, VH		E

Land qualities used in the assessment

Flood hazard. Flood waters can damage crops and infrastructure. The frequency and timing of flooding will determine the impact on the enterprise. Infrequent flood events (less frequent than 1:10 years) are not likely to have a major impact, especially if they occur when the flood occurs when there is no crop in the ground. On land with a moderate flood risk it would be advisable to crop only in summer and not establish permanent irrigation systems. For land with a high risk the best option would to select another site.

***Land instability*.** Highly instable land should be avoided as cropping can increase the risk of soil movement. This is likely to lead to the loss of crops and damage to infrastructure.

pH affects nutrient availability to plants and extremes can lead to toxicity or deficiencies. In horticultural enterprises, pH imbalances can be managed with the application of fertilisers, lime or gypsum.

Phosphorus export. Annual horticulture involves relatively high fertiliser inputs that increase risk of nutrient export. Some may feel that the ratings presented here are lenient. This is because the ratings are designed for broad-scale map units in which proximity to waterways has not been considered. Any on-site assessment should consider this. A soil with good nutrient retention properties located directly adjacent to a drain has a higher risk than a soil with poor retention qualities hundreds of metres away. Management options include soil amendment, subsoil drainage, buffer strips and efficient irrigation and fertiliser scheduling[21]. With low volume irrigation systems such as trickle there is a reduced risk of nutrients leaching below the root zone compared with high volume sprinklers.

[21] More on management practices to limit nutrient export in Lantzke and Galati (1997) and Section 11.3 of Tille *et al. 2001*

Rooting depth. As most annual crops are shallow-rooted, a moderate rooting depth (>50 cm) will not present a significant limitation to capability. For soils with a moderately shallow rooting depth (30-50 cm) management options will depend on the nature of the impeding layer. For example, limestone can be removed on some properties (even on shallow soils) or weak pans may be broken by deep ripping.

Salinity. Saline sites or those at hazard of becoming saline should be avoided as irrigation is likely to increase the risk. Some crops will tolerate slight salinity levels while in other crops yields will be significantly reduced[22]. On land with a partial or low hazard, salinity and watertables surveys could be used to identify areas that can be safely planted.

Site drainage potential. In high rainfall areas poor site drainage potential results in seasonal waterlogging and inundation, while in low rainfall areas land may be unsuitable for irrigation without remedial work such as soil amendment and provision of additional drainage.

Soil water storage. Shallow-rooted annual crops require regular irrigation in the summer. Careful irrigation scheduling is essential on soils with very low soil water storage such as the pale deep sands (i.e. high frequency applications of smaller volumes). Soil amendment with organic matter and other material is another solution.

Soil workability is an essential as at least 15 cm of soil is required regular cultivation.

Trafficability areas with very poor machinery access (due to slope, rock outcrop or waterlogging) are considered unsuitable due to the limited options for cultivation, harvesting and weed and pest control.

Water erosion. The risk of water erosion is relatively high due to regular soil disturbance through cultivation and harvesting activities. On most soils located on slopes with gradients in excess of 10% the risk is considered to be limiting. Management options on areas with a moderate hazard include cross slope working, minimising cultivation, the use of narrow-tyned implements, basin tillage and the establishment of cover crops after harvest[23].

Water repellence is common on sandy soils. Though it can adversely affect production it is routinely managed by irrigation scheduling, land layout (e.g. furrows) and wetting agents.

Waterlogging and inundation can be major restrictions, especially in the winter months. Land with a moderate hazard is considered suitable for summer cropping only. Other management options include construction of artificial drainage or permanent raised beds.

***Wind erosion*.** As with water erosion, regular soil disturbance through cultivation and harvesting increases the risk of wind erosion. Associated sand blasting can damage crops. Control measures include timing of cultivation, irrigation to keep soils moist and the use of wind breaks (trees, shrubs or artificial barriers such as shadecloth).

Other land use notes

Root crops. In Table 3.2, a soil has suitable depth for annual horticulture if there is no physical barrier to root penetration in the top 50 cm. For some root crops in which the shape of the tuber is an important consideration for marketing (e.g. potatoes, carrots and Chinese radish) the presence of gravel and other coarse fragments will reduce the suitability of some soils. For such crops, the rating table should be modified to include the coarse fragment land characteristic (Section A1.1). For other root crops such as processing potatoes where tuber shape is not so important, the rating table may be adequate. However, gravels may also hamper harvesting, which again would require a modified rating for the presence of coarse fragments.

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22 Department of Agriculture Farmnotes 34/2004 ‘Water salinity and crop irrigation’ and 71/1999 ‘Tolerance of plants to salty water’ provide some indication of the tolerance of different horticultural crops to salinity.

23 More details on management practices to limit water erosion can be found in Rose (1997) and Section 9.3 of Tille *et al.* (2001).

3.3 Land capability for perennial horticulture

The assessment for perennial horticulture covers production of irrigated horticultural crops on plants with long life-cycles (typically trees, shrubs or woody vines). Included are orchard crops (e.g. apples, citrus, stone fruit, avocados, nuts, etc.) and vineyard crops (e.g. grapes and kiwifruit). Although the plants are perennial, crops are harvested annually.

The assumptions for the land use as assessed include:

- crops are grown for commercial production
- plants are deep-rooted with roots typically extending to depths of 100 cm or more
- plants are irrigated using drip, micro-jet or mini-sprinkler systems
- fertilisers and herbicides, fungicides and/or pesticides are broadcast at least annually
- mechanised cultivation occurs only during crop establishment
- weeds are controlled by mowing, slashing or sprays
- machinery access to the crop is required for spraying, pruning and/or harvesting
- considers physical requirements only and ignores socio-economic factors.

Class 1 or 2 land has the greatest versatility in this assessment, there being few production or environmental limitations for a wide range of crops. Some class 3 has land has moderate limitations for most crops while some may have a high capability for individual crops that can tolerate a wide range of soil conditions (e.g. wine grapes), but be unsuited to other crops with more restrictive requirements (e.g. avocados). Class 4 and 5 land will be unsuitable for most crops, although there may be some individual crops with specific requirements and tolerance which can be grown on this land.

It should be remembered that the ratings derived from these tables relate to the suitability of the land resource only. They do not take into account factors such as the availability and quality of water supplies for irrigation or climatic risks such as frost or heat stress. Such factors need to be considered as a separate layer of information.

Table 3.3. Land capability ratings for perennial horticulture

Land quality and (capability subscript)	Land capability class				
	1	2	3	4	5
Flood hazard *(f)*	N	L	M		H
Land instability *(c)*	N, VL, L		M		H
pH 0-10 cm *(zf)*	Slac, N	Mac, Sac, Malk	Vsac		
pH 50-80 cm *(zg)*	Slac, N	Mac	Vsac, Sac, Malk, Salk		
Phosphorus export *(n)*	L	M, H	VH	E	
Rooting depth *(r)*	D, VD	(M)	M	MS	S, VS
Salinity hazard *(y)*	NR		PR	MR	HR, PS
Salt spray exposure *(zi)*	N			S	
Surface salinity *(ze)*	N		S	M	H, E
Site drainage potential *(zh)*	R, W	MW	M	P	VP
Soil water storage *(m)*	H, M, ML	L	VL		
Soil workability *(k)*	G	F	P	VP	
Subsurface compaction *(zc)*	L, M	H			
Trafficability *(zk)*	G	F	P	VP	
Water erosion *(e)*	VL, L	M	H	VH	E
Water repellence *(za)*	N, L, M	H			
Waterlogging *(i)*	N	VL (L)	L (M)	M (H)	H, VH
Wind erosion *(w)*	L	M, H	VH		E

Brackets ( ) indicate adjustments for wine grapes.

Land qualities used in the assessment

The major differences from annual horticulture are that plants are long-lived and generally deeper-rooted, irrigation systems are more permanent and regular cultivation is not necessary.

Phosphorus export, Site drainage potential, Salinity, Soil water storage, Trafficability and ***Water repellence.*** See comments for annual horticulture.

Flood hazard and ***Land instability.*** Flood waters and mass movement can damage crops and infrastructure. The impact may be greater than for annual horticulture as the crops and irrigation systems are more permanent. Levee banks could be considered to protect against flooding in some situations.

pH affects nutrient availability to plants and extremes of pH can lead to toxicity or deficiencies. In the topsoil, pH imbalances can be managed through the application of fertilisers, lime or gypsum. Subsoil pH can be difficult to manage once the crop is established though ameliorants can be deep ripped into the soil prior to planting. In some cases subsoil pH will be a limitation to rooting depth.

Rooting depth. Any soil less than 50 cm deep is considered unsuitable for most perennial crops. Having in excess of 80 cm of profile for the roots to exploit is preferable. In some cases mounding may be employed to increase available soil depth.

Soil workability is usually less limiting than for annual horticulture as soil is not cultivated following crop establishment.

Subsurface compaction. As traffic is confined to inter-row spaces, compaction and reduced root growth can result. Traffic pan can be treated through deep ripping though this may have detrimental impacts on the roots of some species.

Water** and **Wind erosion. Limited cultivation reduces erosion risk in comparison to annual horticulture. On slopes with gradients in excess of 10%, rows should be laid out on a slight gradient off the contour with ground cover being maintained between the rows. Inter-row cover can consist of sod culture (grasses), cover crops (e.g. oats or lupins), or mulches (e.g. straw). Slopes with gradients in excess of 15% should generally be avoided

Waterlogging tolerance varies between crops and land with a low waterlogging risk will be suitable for some crops but not others. Deciduous trees and vines (e.g. grapes) have a greater tolerance of winter waterlogging during crop dormancy than evergreen species such as citrus and avocados. Few crops are tolerant of waterlogging in late spring and summer. Careful assessment of waterlogging risk in spring from seasonal variations in rainfall is recommended.

Other land use notes

Wine grapes. The ratings table for perennial horticulture shows adjustments for wine grapes. These have a greater tolerance to waterlogging and shallower rooting depth requirement than most other crops. Some growers prefer soils with rooting depth limitations as this gives them more control over water availability and grape quality (e.g. through the practice of Regulated Deficit Irrigation).

Some good viticulture soils occur on land with >15% slopes. For smaller orchards, if machinery access is not essential, this land can be highly productive.

3.4 Land capability for grazing

This assessment covers the grazing of sheep and cattle on broadscale dryland (i.e. non-irrigated) pastures in agricultural areas (receiving an average annual rainfall more than 350 mm).

Pastures are typically based on annual species (such as sub-clover or ryegrass), but perennial species (such as kikuyu or perennial ryegrass) are often present in higher rainfall areas and may dominate some locations. This land use incorporates occasional reseeding and fertiliser topdressing using tractors or similar machinery.

This assessment does not apply to irrigated pastures or to intensively managed paddocks (where supplementary feeding is essential due to high stocking rates and windbreaks are necessary to control wind erosion). See notes on stocking rates, small holdings and horses below. Tables 3.4a considers physical requirements only and ignores socio-economic factors.

Table 3.4a. Land capability ratings for grazing

Land quality and (capability subscript)	Land capability class				
	1	2	3	4	5
Flood hazard *(f)*	N, L	M	H		
Land instability *(c)*	N, VL, L		M	H	
pH 0-10 cm *(zf)*	Slac, N	Sac, Mac, Malk	Vsac, Salk		
pH 50-80 cm *(zh)*	Slac, N	Mac, Malk, Salk	Sac	Vsac	
Phosphorus export *(n)*	L, M	H	VH	E	
Rooting depth *(r)*	VD, D, M	MS	S	VS	
Salinity hazard *(y)*	NR	PR	MR	HR	PS
Salt spray exposure *(zi)*	N		S		
Surface salinity *(ze)*	N	S	M	H	E
Surface soil structure decline *(zb)*	L, M	H			
Soil water storage *(m)*	M, H	ML	L	VL	
Soil workability *(k)*	G, F, P		VP		
Subsurface acidification *(zd)*	L, M	P, H			
Subsurface compaction *(zc)*	L, M	H			
Trafficability *(zk)*	G, F	P	VP		
Water erosion *(e)*	VL, L, M	H	VH	E	
Water repellence *(za)*	N, L	M	H		
Waterlogging *(i)*	N, VL, L	M	H	VH	
Wind erosion *(w)*	L	M	H	VH	E

Land qualities used in the assessment

Flood hazard is only severe if flooding would affect pasture production or endanger grazing animals.

Land instability. The clearing of native vegetation increases the risk of mass movement. The impact on a grazing system will not be great but there could be some loss of pasture and damage to fences. Increasing water use upslope (e.g. through tree planting) reduces risk of mass movement. Areas where landslides have already occurred should be fenced and revegetated[24].

pH. Highly acid soils reduce production of most legume species. Management options include growing tolerant species and using acid-tolerant Rhizobia and/or applications of lime. Medics can be selected for highly alkaline soils.

Phosphorus export. Although grazing involves less intense fertiliser applications than horticulture, larger areas are fertilised. Livestock redistribute the nutrients by grazing pastures over a broad area then depositing manure and urine in concentrated patches. This can make a significant contribution to nutrient export, where nutrients are deposited close to waterways, especially in stock camps under shade trees along water courses. Management practices include matching fertilisers to pasture requirements, timing of fertiliser applications and the creation of buffer strips along waterways[25].

Rooting depth. Except on very shallow soils, rooting depth is unlikely to be a significant limitation for shallow-rooted pastures. However, rooting depth does impact on soil water storage, hence pastures dry out rapidly.

Salinity can be a serious limitation to production while the establishment of low water use annual pastures contributes to development of salinity. Land with high to extreme surface salinity is generally unsuited to conventional grazing though some productivity from saltland pastures may be possible. Management of affected areas can include increasing plant water use in recharge areas, improving site drainage and establishment of salt tolerant pastures[26].

Soil water storage. On soils with very low water storage, pastures are less productive and dry off rapidly. Poor ground cover increases the risk of wind and water erosion as well as contributing to recharge leading to the development of salinity.

Surface soil structure decline, Subsurface acidification, Subsurface compaction and ***Water repellence*** all affect pasture production but are rarely prohibitive. Management practices to control and alleviate these problems have been developed[27]. However wide scale adoption has yet to be achieved and land is still deteriorating in many areas. Adoption is more economic in higher rainfall areas where there is greater production per hectare.

Trafficability. Access for broadcasting fertiliser and herbicides/pesticides, as well as reseeding and stock management, is generally required. Alternatives to conventional tractors are available for areas with difficult access such as steep rocky slopes.

Water erosion and ***Wind erosion*** generally lead to a slow decline in productivity, though extreme events can have a more immediate impact. Management can include excluding

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24 More details on dealing with mass movement can be found in Section 10.3 of Tille *et al.* (2001).

25 More details on combating nutrient export can be found in Section 11.3 of Tille *et al.* (2001).

26 More details on managing salinity can be found in Moore (1998b) and Section 5.3 of Tille *et al.* (2001).

27 See Sections 3.1, 3.2, 4 and 5.1 of Moore (1998a) for more details.

stock from highly susceptible areas, maintaining ground cover through control of stocking rates, the construction of earthworks to control runoff and the establishment of windbreaks[28].

Waterlogging can limit pasture production with varying degrees of severity. The effects of waterlogging are often far from obvious. Mildly waterlogged pastures can look healthy but have significant yield reductions. Management options include the uses of waterlogging tolerant pasture species and the construction of surface drains[29].

Other land use notes

Cropping or hay production. In many areas crops are grown in rotation with pastures. Land capability for cropping is assessed separately in the next section.

Stocking rates. Table 3.4b indicates the approximate correlation between the land capability classes derived above and the carrying capacity for improved clover pastures in high rainfall areas (>600 mm).

For **small holdings** such as rural residential developments of 1-2 ha (or more), the land use description for grazing differs from the one given above for Table 3.4a. As a result the capability ratings and stocking rates for a parcel of land will not necessarily be the same as those presented in Table 3.4b. On small holdings there tends to be a higher rate of management, with less reliance on pasture and more imported feed. Stock are often stabled overnight allowing for management of manure and pastures may be irrigated.

A 2 ha lot of class 5 land capable of supporting only one fifth of a horse according to Table 3.4b may be suitable to support one or two horses with suitable management. **Horses** are generally more active than other livestock and require better paddock management to prevent soil erosion. Horses also tend to be slightly more destructive to unprotected trees by eating the bark (ring barking in some seasons), even when adequate pasture is available. Issues such as manure handling, fly control and odour are common.

So when considering small rural holdings, such management factors are very important considerations. Planning or management guidelines for small rural holding should **not** be developed directly from the stocking rates in Table 3.4b, but need to consider the specific management options available to the stock being considered[30].

Table 3.4b. Correlation between land capability classes and carrying capacity for improved clover pastures in high rainfall areas (>600 mm)

Capability class	Approximate carrying capacity (DSE*/ha)
1 - Very High	7-10
2 - High	7-10
3 - Fair	4-7
4 - Low	1-4
5 - Very Low	≤1

* DSE is dry sheep equivalent. Stocking rates for other animals can be calculated as large horse = 10 DSE; pony = 8 DSE; milking cow = 10 DSE; heifer = 8 DSE; breeding ewe = 1.5 DSE; dairy goat = 2 DSE; Cashmere goat = 1 DSE; angora goat = 0.8 DSE; deer = 1-2 DSE.

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28 See Sections 7.1 and 7.2 of Moore (1998a) and Section 9.3 of Tille *et al.* (2001) for more details.

29 See Sections Moore and McFarlane (1998) and Section 7.3 of Tille *et al.* (2001) for more details.

30 More information on stocking rate guidelines for rural small holdings in van Gool *et al.* (2000).

3.5 Land capability for dryland cropping

This assessment covers the production of rain-fed (non-irrigated) field crops under a cropping system that incorporates minimal tillage practices and stubble retention.

Crops included in this general assessment are wheat, barley, oats, narrow-leafed lupins, field peas, canola, chickpea and faba beans.

Table 3.5 assumes that the cropping system incorporates minimal tillage practices. This involves the mechanised tillage of the entire topsoil in a single pass, usually at time of sowing. Typically, minimum tillage is carried out using wide points on a combine seed drill or air seeder, or using a culti-trash seeder or offset discs. The table also assumes that the stubble is retained after cropping on soils prone to wind erosion. Adjustments for assessments for traditional tillage (involving two weed-control workings before sowing using wide points and resulting in greater risk of erosion and non-wetting problems) are shown in brackets.

This is a general assessment for common dryland crops grown over extensive areas (i.e. hundreds of hectares). It is best suited to the 350-600 mm rainfall zone where most extensive crops are grown (i.e. the wheatbelt), though may be extended to include some slightly higher rainfall areas. Different crops have varying tolerance to soil properties such as pH, salinity and waterlogging, therefore separate land capability ratings tables can be prepared for each of the main crops. Land capability tables for wheat, barley, oats, canola and lupins can be found in Appendix 5.

In this assessment, class 1 or 2 land has the greatest versatility, there being few production or environmental limitations for a wide range of crops. Capability class 3 has moderate to high limitations for some or all crops. Some class 3 land may have a high capability for individual crops (such as cereals) that can tolerate a wide range of soil conditions, but be unsuited to other crops (e.g. lupins or faba beans). Class 4 and 5 land will be unsuitable for most crops, although there may be some individual crops with specific requirements and tolerance which can be grown on this land.

Table 3.5. Land capability ratings for dryland cropping using minimum tillage

Land quality and (capability subscript)	Land capability class				
	1	2	3	4	5
Flood hazard *(f)*	N, L		M	H	
Land instability (c)	N, VL, L		M	H	
pH 0-10 cm *(zf)*	N, Slac	Mac, Malk	Sac, Vsac	Salk	
pH 50-80 cm *(zg)*	N, Slac	Mac, Malk	Sac, Salk	Vsac	
Phosphorus export *(n)*	L	M, H	VH (H)	E (VH)	
Rooting depth *(r)*	D, VD	M	MS		S, VS
Salinity hazard *(y)*	NR		PR	MR, HR	PS
Salt spray exposure *(zi)*	N			S	
Surface salinity *(ze)*	N		S	M	H, E
Surface soil structure decline *(zb)*	L	M	H		
Soil water storage *(m)*	H	ML, M	L	VL	
Soil workability *(k)*	G	F		P	VP
Subsurface acidification *(zd)*	L	M	H, P		
Subsurface compaction *(zc)*	L	M, H			
Trafficability *(zk)*	G	F		P	VP
Water erosion *(e)*	VL	L	M	H	E, VH
Water repellence *(za)*	N, L	M, H	(H)		
Waterlogging *(l)*	N, VL	L	M	H	VH
Wind erosion *(w)*	L	M	H, VH, (M)	(H)	E, (VH)

Brackets ( ) indicate adjustments for traditional tillage.

Land qualities used in the assessment

The most significant difference between grazing and dryland cropping is that cropping involves regular cultivation of the land. Crops tend to be deeper rooted than pasture species.

Flood hazard. Floods can damage crops greatly reducing the yield. Areas prone to flooding also have a higher risk of water erosion.

Land instability. Areas susceptible to mass movement would usually also have water or wind erosion limitations.

pH. Extremes of pH affect the availability of nutrients resulting in deficiencies and/or toxicities that adversely affect production. Management options are limited to growing tolerant crops or the use of lime to increase the pH of acid soils.

Phosphorus export. Cultivation for cropping increases susceptibility to erosion, the main mechanism for export in most soils except bleached sands, which do not readily bind phosphorus. Management practices to reduce the risk of nutrient export include reducing risk of soil erosion, matching fertilisers to crop requirements, the creation of buffer strips along waterways and growing crops such as canola and chickpeas which use phosphorus more efficiently[31].

Rooting depth. Shallow soils limit the volume that can be explored by roots and therefore impact on moisture availability. Most crops require at least 30-50 cm depth of soil, but moisture availability, not the rooting depth, will tend to restrict growth unless rainfall is plentiful. For this reason at least 50-80 cm is preferable.

Salinity. Crop tolerance to salinity varies, with lupins being highly sensitive and barley being more tolerant. It is the combination of salinity and waterlogging that has the greatest impact on crops. Management of affected areas can include increasing plant water use in recharge areas, improving site drainage and establishment of salt tolerant pastures[32].

Surface soil structure decline can reduce infiltration, delay seeding because cultivation is restricted to a narrow range of water content and reduce seedling emergence. Management options include minimising tillage, increasing organic matter and the use of gypsum to help stabilise structure on dispersive soils[33].

Soil water storage. Soils with very low water storage are likely to limit yields in most seasons, while those with low water storage are likely to limit yields in low rainfall seasons or where distribution of the rainfall is irregular. Poor ground cover associated with low yields increases the risk of wind and water erosion as well as contributing to recharge leading to the development of salinity. Deep-rooted crops such as lupins are an option on deep sands with low soil water storage.

Soil workability. Rock outcrops and large stones on or near the surface make cultivation difficult and can damage machinery. Small surface stones and rocks can be pushed into heaps in many areas so they do not hinder cultivation. Heavy soils can also be hard to work, especially if they are sodic.

Subsurface acidification results in increased solubility of aluminium which is toxic to plants and reduces the rate of root elongation, which limits crop access to water and mobile nutrients like nitrogen. Management options include growing tolerant crops and the application of lime. Subsurface acidification is a severe problem which takes many years to develop. Once developed it can take many years to ameliorate. Continual applications of lime on the surface will eventually have an effect on the subsoil, but not until the topsoil pH has been improved (Mike Bolland, pers. comm.)[34]. Deeper applications of lime so far have had limited success, but may become viable in some situations.

Subsurface compaction produces a barrier to root penetration and hence limits crop access to water and mobile nutrients such as nitrogen. Management may include deep tillage to disrupt the traffic pan[35].

Trafficability. Mechanisation using large machinery is essential for broadscale cropping as practised in WA.

Water erosion can reduce crop yields; result in the loss of nutrients and reduce productive potential. As a general rule, the risk of water erosion is likely to become limiting on slopes with gradients in excess of 10 per cent. Management options include the adoption of no-till

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[31] More details on combating nutrient export can be found in Section 11.3 of Tille *et al.* (2001).

[32] More details on managing salinity in Moore (1998b) and Section 5.3 of Tille *et al.* (2001).

[33] See Needham *et al.* (1998a) for more details on managing structure decline.

[34] See Moore *et al.* (1998a) for more details on managing soil acidification.

[35] See Section 4 of Moore (1998a) for more details on managing subsurface compaction.

systems, sowing on the contour and installing banks to control the length of slope and/or reduce waterlogging[36].

Water repellence leads to uneven infiltration which can result in lower soil moisture, poor seedling germination, patchy crop growth and increased weed establishment. Increased run-off can contribute to soil erosion and nutrient loss and loss of applied herbicides. Furrow sowing, wetting agents and clay additions are the main management options[37].

Waterlogging reduces crop yields especially if it occurs early in crop development or when the temperatures are higher in spring. Management options include cropping on raised beds, improved site drainage and/or growing tolerant crops such as oats or faba beans[38].

Wind erosion can result in sand blasting, the loss of nutrients and long-term loss of productive potential. Crops should be sown into stubble on soils with high susceptibility[39].

Other land use notes

This is a general assessment covering a wide range of crops. Ratings tables have been developed for five specific crops: wheat, barley, oats, canola and lupins. These ratings are presented in Appendix 5.

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[36] See Coles and Moore (1998) and Section 9.3 of Tille *et al.* (2001) for more details on water erosion.

[37] See Moore and Blackwell (1998) for more details on managing non-wetting.

[38] See Moore and McFarlane (1998) and Section 7.3 of Tille *et al.* (2001) for more on waterlogging.

[39] See Moore *et al.* (1998b) for more details on managing wind erosion.

3.6 Land capability for septic tanks for rural residential development

This assessment covers the physical capability of land to absorb and purify effluent coming from traditional septic tanks servicing a single family dwelling on a block of 1 ha or larger.

Table 3.6. Land capability ratings for septic tanks for rural residential developments

Land quality and (capability subscript)	Land capability class				
	1	2	3	4	5
Ease of excavation *(x)*	H	M	L	VL	
Flood hazard *(f)*	N		L	M	H
Land instability *(c)*	N	VL	L	M	H
Microbial purification ability *(p)*	H	M	L	VL	
Soil absorption *(zj)*	H	M	L	VL	
Waterlogging *(i)*	N, VL	L	M	H	VH

Land qualities used in the assessment

Ease of excavation not only relates to the installation of septic tanks but will also affect house and road construction and provision of services.

Any land subject to ***flood hazard*** or ***land instability*** is not suited to septic tanks or housing developments. Management will depend on the nature and extent of the problem.

Microbial purification ability assesses the soils capacity to purify added effluent. Management options are similar to waterlogging.

Waterlogging. An insufficient volume of well aerated material reduces the soil's ability to purify septic tank effluent. Problems are encountered where the watertable is close to the surface. In these situations, preferred management options include alternative methods for handling household effluent such as aerobic treatment units or Ecomax™ which utilise leach drains where the soil is amended with bauxite residue, or small local treatment plants. Less desirable is the provision of a large sand pad to elevate leach drains 2 m above the highest seasonal watertable.

Other land use notes

Rural residential developments. Ratings for septic tanks can be combined with ratings for the relevant agricultural uses when undertaking assessments for rural residential developments. Most rural residential developments in WA use septic tank effluent disposal. Hence land capability for septic tanks should be a minimum requirement.

Where orchards, market gardening or grazing are part of the proposed development, these ratings should also be considered. However, the agricultural ratings may need to be adjusted depending on the land use assumptions associated with the rural residential developments. For example, small scale horticulture may not involve the same emphasis on machinery access as indicated in the ratings tables. Livestock and pasture management may be quite different to the assumptions for broad-scale grazing of non-irrigated pastures[40]. In such cases management and development requirements will determine suitability.

Urban developments. Urban developments usually include the construction of building and roads as well as the provision and maintenance of drains, sewers and garden areas. These are intensive land uses for which the land use and development assumptions are highly variable. The amount of capital normally invested means that engineering solutions are used

[40] See notes on small holdings in Section 3.4.

more routinely than for less intensive land uses. As a result, considerations such as the relative land values and proximity to existing infrastructure play a much larger role in the ultimate selection of urban land irrespective of initial land capability.

Large developments can pay to overcome problems more readily than smaller developments. For example, in some coastal areas entire dunes are often removed or levelled, and even large swamps are filled or drained, hence issues such as wind erosion and waterlogging may not be considered serious impediments to development.

As a *general* guide, urban land capability suits similar areas to perennial horticulture, however a land capability ratings table is not provided because engineering solutions are used to overcome limitations.

Extensive land degradation problems can still be (or should have been) an impediment to urban development. Contemporary examples in WA are secondary salinity that now affects many rural towns prompting a rescue program as part of the Salinity Action Plan (Government of Western Australia 1996). Similarly, nutrient pollution problems in most streams and wetlands on the Swan Coastal Plain are well documented and have been funded under government programs including the Peel-Harvey Catchment Management Program (e.g. ERMP Stage 2, Kinhill Engineers 1988). This included the provision of the Dawesville Cut – a massive new channel for flushing the Peel Inlet and Harvey Estuary.

3.7 Displaying capability ratings on maps

Virtually all of the Department of Agriculture's soil-landscape mapping units comprise a number of unmapped land units covering the variation of soils and landscapes within the map unit (see Section 1.4 – Proportional mapping). As these land units typically have a range of capability ratings, it is uncommon for a single rating for any land use to apply to the entire map unit. This presents a challenge when representing capability ratings cartographically. Two methods of displaying capability ratings on maps that are used routinely in WA are discussed below (e.g. see the AGMAPS CDs e.g. DoA 2005).

Single value percentage capability maps

When proportional mapping has been used the legend can either show high or low capability land greater or less than a particular per cent. For example a percentage map legend showing very high (class 1) and high (class 2) capability land.

Map legend

High or Very high land capability for 'land use x'

>70%

50-70%

30-50%

<30%

0%

The cut-off values used in the example are a good starting point for many regional scale surveys and the land uses described in this report. However it is not uncommon to introduce additional categories. Maps produced should be carefully considered before being used for important policy or planning decisions. It is not unusual for the look of a map to change dramatically depending on whether, for example >10 per cent or ≥10 per cent is used. This is because proportional allocations are often rounded to the nearest 5 or 10 per cent, hence 10 per cent is likely to be much more common than 11 per cent. In the absence of additional land resource information, it is now fairly common practice to utilise 'expert' opinion and local knowledge to help judge if maps are a good representation of reality.

The advantage of single value percentage maps is that they are simple to interpret. It is often desirable to keep the null (0%) value to show map units where no high or very high capability land occurs at all. However, a disadvantage in the example above is that the map does not indicate if the remaining land is low or fair capability. For example a map might be 0 per cent classes 1 and 2, however all the remaining land might be class 3, hence 0 per cent classes 1 and 2 does not necessarily indicate low capability. To overcome this you might also prepare a map which shows classes 1, 2 and 3 grouped, as well as a map showing classes 4 and 5. Unfortunately the number of maps created quickly gets out of hand, particularly if considering several land uses. An alternative is to provide a coded range of values that combines high fair and low capability land on one map. This is considered in the following section.

Coded proportional land capability maps

A technique for displaying capability on maps involves reducing the five classes to three by combining classes 1 and 2 (high capability) and combining classes 4 and 5 (low capability). The map unit is then classified as:

- **Category A land** if there is 50% or more high capability zone land units (A1 if there is 70-100% high capability and A2 if there is 50-69%).
- **Category B land** if there is less than 50% high capability zone land units but 50% or more moderate or high capability zone land units (B1 if there is 70-100% moderate capability and B2 if there is 50-69%).
- **Category C land** if there is 50% or more low capability zone land units (C1 if there is 50-69% low capability and C2 if there is 70-100%).

For example 5% of one map unit may have a Class 1 rating for a given land use, with 35% having a Class 2 rating, 20% having a Class 3 rating, 30% having a Class 4 rating and 10% having Class 5 rating. The map unit described here has 40% high capability zone land units, 20% moderate capability and 40% low capability zone land units. This is not enough to qualify as Category A land, but as there is 60% moderate to high capability it becomes Category B2. Figure 7 shows a standard legend for a capability map, while Figure 8 demonstrates the categories graphically with the aid of a capability triangle.

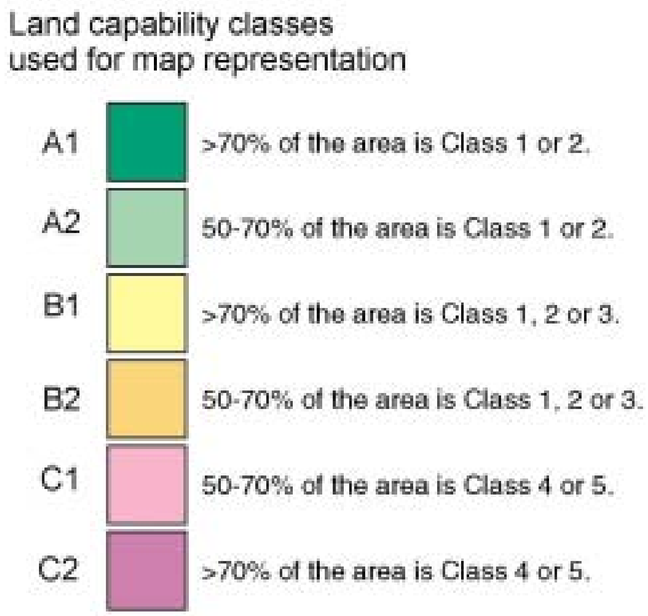

Figure 7. Standard capability map key

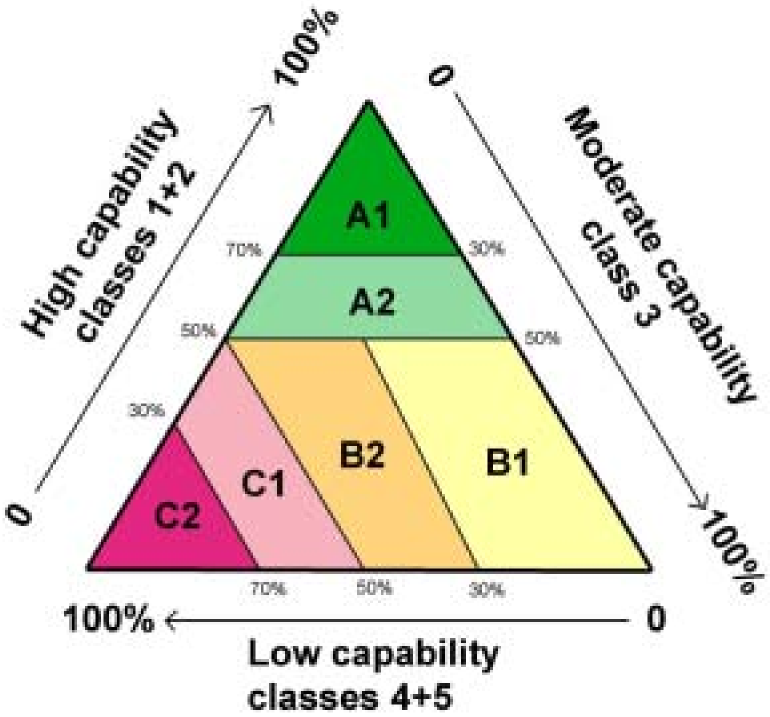

Figure 8. Land capability triangle

Land capability SQL statements for six areas, combining class 1, 2 and 3 land
Iif([AH1 and 2] > 69, ’A1’, Iif ([AH1 and 2] > 49, ’A2’, Iif ([AH12 and 3] > 69,’B1’, Iif ([AH12 and 3] > 49, ’B2’, Iif ([AH12 and 3] > 29,’C1’, ’C2’))))))

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