Grains Research & Development Corporation

Review of the use and potential for dual purpose crops

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1 INTRODUCTION AND BACKGROUND

In the Australian wheat-sheep belt, the majority of farms are mixed - both crop and livestock enterprises can occur on each farm. This mixed farming system has prevailed for more than a century because of the relatively infertile nature of Australian soils. A legume pasture–livestock ley (Puckridge and French 1983) or phase (Reeves and Ewing 1993) provides farmers with opportunities to exploit the potential synergies (positive interactions) of mixed farming, embracing the provision of high quality fodder for livestock, an improvement in soil nitrogen content for crops, a reduced exposure of farms to the risk of crop failures, and the impact of pasture-crop rotations on weed, disease and pest cycles (Wolfe and Cregan 2003). Other effects may be complementary (additive), such as the consumption of weeds by livestock, thereby reducing weed populations in subsequent crops, and the benefit to animals and to crop sowing operations from the consumption of crop residues. Negative interactions come from *antagonistic* effects, such as the distribution of some crop weeds by livestock and *competition* between enterprises for labour, resources or investment. A neutral (*supplementary*) relationship occurs when the expansion of one enterprise has little effect upon another; for example, below a certain threshold area, the presence of livestock (grazing crop stubbles, laneways and tree lots) is not competitive with the area allocated for crop production.

During recent decades, there has been a trend away from the livestock component of mixed farm businesses due to declining wool prices. With pressures to increase farm size, enhance productivity and deal with a lower availability of quality farm labour, most mixed farmers have increased the scale of their cropping operations, sacrificing at least some of the traditional level of diversification. The tension between the forces of specialisation and diversification is one the major factors, along with climate change and input constraints, that are at the heart of the future of broad-area farming in Australia. Currently, there is renewed interest in optimising livestock and cropping activities, due to problems in sustaining intensive cropping systems and to movements in the relative profitability and risk of both meat and grain production, especially in drier years.

The focus of this review is on the potential to expand the dual purpose crops for grazing (forage) and grain production, an archetype of mixed farming. What then defines dual purpose crops?

Dual purpose crops are described as varieties (plant genotypes) that can be sown early and are protected from early reproductive development due to the presence of genes that must be triggered by photoperiod (the winter solstice is important) and/or cold (vernalisation).

Such genotypes can be sown earlier in autumn than normal grain varieties, can adapt to and tolerate grazing as a tool for canopy management and manipulating growth stages during their vegetative stage (May-July), help fill the winter feed gap in the livestock cycle, and recover to produce a grain or hay crop. They are increasingly being used in the high rainfall areas of southern Australia and there is growing demand for validation of varieties in drier agro-ecological zones including the Western and Northern GRDC regions. A list of current grain crops from the 2011 NSW Crop Sowing Guide, identifying dual use varieties, is given at Annex 1.

Reported benefits from grazing cops include filling winter feed gaps for livestock, delayed flowering and subsequent reduction of frost risk, canopy management, and reduced water use during vegetative phase. Questions still remain about the disease risks that may be exacerbated by early sowing, the performance of current dual purpose and mainstream varieties under grazing, including any subsequent grain yield penalties and the traits that could be beneficial for a specific dual purpose breeding program.

GRDC has invested in several dual purpose specific projects in both breeding and management practices. The majority of this work has been conducted in higher rainfall regions with some of the results being extended and validated in medium to lower rainfall areas through current programs such as Grain and Graze 2. Investment has occurred with several crops including wheat, canola and triticale as well as limited support for dual purpose oat breeding by NSW at the Temora research station. Details are given in Annex 2.

The GRDC Southern and Northern panels have identified investment in dual purpose crops as a priority. There is also an increased interest in grazing crops by growers in the Western region with multiple workshops featuring researchers from eastern states presenting information on current practices.

There are several drivers behind a review of current research. These include;

- Growers are currently using existing dual purpose and mainstream cereal varieties for grazing guided by 'rules of thumb' developed and validated through GRDC research
- Market size for specific dual purpose varieties is undetermined and a system for returns through royalties is unclear
- Specific traits for dual purpose crops need to be identified prior to investment in a breeding program
- There is confusion about the wide variety of crops that could potentially be used for grazing and how these crops fit into the farming system to benefit the grower

Accordingly, the GRDC has invited a review team comprising Dr John Radcliffe (Chairman), Dr Hugh Dove, Denis McGrath, Dr Peter Martin and Professor Ted Wolfe to establish the current use and potential need for dual purpose crops in the various agro-ecological production regions as well as their role in the GRDC crop sequencing initiative, and identify any research gaps and make recommendations as to the most efficient and appropriate investment for future dual purpose crop research. Details of the review team are given in Annex 3. The review team was assisted by GRDC staff members Tanya Robinson and Tom Giles.

The review was to be undertaken in three stages. The first step was to establish the current situation including the use and potential for dual purpose crops to be grown in preference to the current grain producing varieties. Included in this assessment was an evaluation of farming practices and agronomic information for growing and managing

1.1 Methodology

Review team members met in Canberra on June 1 2011 to exchange ideas on the topic areas. Discussions were held on developing a regional analysis of dual use crops as described by regional agronomists. This was agreed to be undertaken by personal interview. A survey of growers and consultant agronomists to identify the current extent of adoption of dual use crops, how they are fitted into the farm production system, the bases for doing so, and the extent of flexibility that farmers have in their use was also undertaken. While the survey was being undertaken, an extensive review of available literature was also conducted and analysed. The review team subsequently met in Canberra for follow up interviews/meetings and provide a final debriefing to GRDC.

Draft copies of individual reviewers' responses to the other Terms of Reference were submitted to the Review Chair. After further development of drafts of the review report, the Review Chair submitted the final version of review after sign-off by the Review Team

2 AUSTRALIA'S PRINCIPAL CROPS

Total winter crop production is forecast to be around 41 million tonnes in 2011–12. This would be the fourth largest winter crop on record and is an upward revision from the ABARES June 2011 forecast of 40.8 million tonnes. Favourable conditions and likely higher production in Western Australia, South Australia and Victoria are expected to more than offset lower forecast production in New South Wales and Queensland. Of the major winter crops, wheat production is forecast to be 26.2 million tonnes in 2011–12, slightly lower than last year and is largely unchanged from the ABARES June 2011 forecast. Barley production is forecast to fall by 11 per cent to 8.3 million tonnes while canola production is forecast to increase by 7 per cent to 2.3 million tonnes (ABARES 2011).

Winter crop production by state is shown in Table 1. It will be seen that after a number of particularly poor years (2002-3, 2006-7. 2007-8), crop estimates suggest yield will be high in 2011-12

Table 1. Total winter crop yield and by individual state, 1998-2012 (ABARES 2011)

	New South Wales	Victoria	Queensland	Western Australia	South Australia	Australia
	kt	kt	kt	kt	kt	kt
1998–99	9 718	3 495	2 322	12 232	6 305	34 147
1999–00	11 495	5 139	2 222	13 311	4 751	36 980
2000–01	10 834	6 232	1 340	8 726	7 486	34 696
2001–02	11 171	5 873	1 142	12 050	8 927	39 240
2002–03	3 505	1 955	836	6 812	4 227	17 402
2003–04	10 768	6 945	1 473	16 683	7 451	43 394
2004–05	10 724	4 204	1 383	12 983	5 338	34 710
2005–06	11 983	6 270	1 435	13 947	7 520	41 236
2006–07	3 796	1 751	926	8 279	2 793	17 588
2007–08	4 007	4 700	1 196	10 761	4 706	25 422
2008–09	9 441	3 890	2 326	13 784	4 864	34 386
2009–10	7 789	5 896	1 618	12 950	7 038	35 365
2010–11 **s**	15 259	7 914	1 597	7 406	9 807	42 056
2011–12 previous	12 115	6 204	2 140	12 692	7 577	40 799
2011–12 **f**	**11 274**	**6 438**	**1 876**	**13 192**	**8 171**	**41 021**
% change 2010–11 to 2011–12	*-26*	*-19*	*17*	*78*	*-17*	*-2*

a State production includes wheat, barley, oats, triticale, canola, lupins, field peas, chickpeas, faba beans and lentils. Australian totals also include linseed and safflower. **f** ABARES forecast. **s** ABARES estimate.

Yield of individual crop species is shown in table 2. Wheat remains by far the dominant field crop in terms area planted and total production (ABARES 2011). It is not possible to identify from deliveries what is the net worth of dual purpose crops in Australia

Table 2. Five year average and total area planted, yield rate and total production for 2009-10, 2010-11 and 2011-12 for Australia's principal field crops (ABARES 2011)

	area planted				yield				production			
	Five-year average **a**	2009–10	2010–11 **s**	2011–12 **f**	Five-year average **a**	2009–10	2010–11 **s**	2011–12 **f**	Five-year average **a**	2009–10	2010–11 **s**	2011–12 **f**
	'000 ha	'000 ha	'000 ha	'000 ha	t/ha	t/ha	t/ha	t/ha	kt	kt	kt	kt
Wheat	13 032	13 881	13 374	14 108	1.42	1.57	1.97	1.86	18 794	21 834	26 325	26 196
Barley	4 520	4 422	4 077	4 118	1.63	1.78	2.29	2.02	7 323	7 865	9 334	8 312
Oats **b**	976	850	917	1 003	1.27	1.37	1.68	1.56	1 222	1 162	1 536	1 563
Triticale	346	350	330	330	1.31	1.56	2.07	1.75	448	545	685	580
Grain sorghum **b**	691	498	637	617	3.20	3.03	3.36	3.03	2 282	1 508	2 137	1 867
Maize	60	59	61	54	5.55	5.56	5.75	5.55	336	328	351	300
Canola	1 475	1 712	1 642	1 705	1.00	1.12	1.30	1.35	1 537	1 920	2 136	2 293
Sunflower	36	27	29	26	1.32	1.54	1.51	1.25	47	41	44	33
Cottonseed **c**	234	208	590	600	2.66	2.63	2.15	2.69	571	547	1 269	1 617
– lint	234	208	590	600	1.92	1.86	1.52	1.90	410	387	898	1 144
Rice	28	19	89	101	8.78	10.39	9.04	9.02	250	197	807	909
Lupins **d**	665	692	568	490	1.00	1.19	1.09	1.42	656	823	618	694
Field peas **d**	311	285	292	244	0.96	1.25	1.49	1.57	287	356	434	384
Chickpeas **d**	381	429	546	285	0.99	1.14	0.69	1.43	370	487	379	407
Faba beans **d**	144	129	145	151	1.27	1.68	1.98	1.81	177	217	287	275
Lentils **d**	143	104	159	173	1.00	1.38	1.93	1.75	135	143	306	303

a Based on data from ABS, *Principal Agricultural Commodities*, cat. no. 7111.0, five years to 2010–11; ABS, *Agricultural Commodities, Australia*, cat. no. 7121.0; Pulse Australia. **b** Area harvested for grain. **c** Cottonseed area is estimated harvested area. **d** *Source:* Pulse Australia. **s** ABARES estimate. **f** ABARES forecast.
Note: The crop year refers to crops planted during the 12 months to 31 March. Winter crops are generally both sown and harvested within the nominated 12 month period. Slight discrepancies may appear between table 1 and tables 2 and 3 as a result of the inclusion of the Australian Capital Territory and Northern Territory in the Australian totals. Area and production estimates are from the sources detailed in footnotes to tables 2 and 3. Coverage is for all farms with an estimated value of agricultural operations of more than $5000.

The principal wheat-growing areas are shown in figure 1

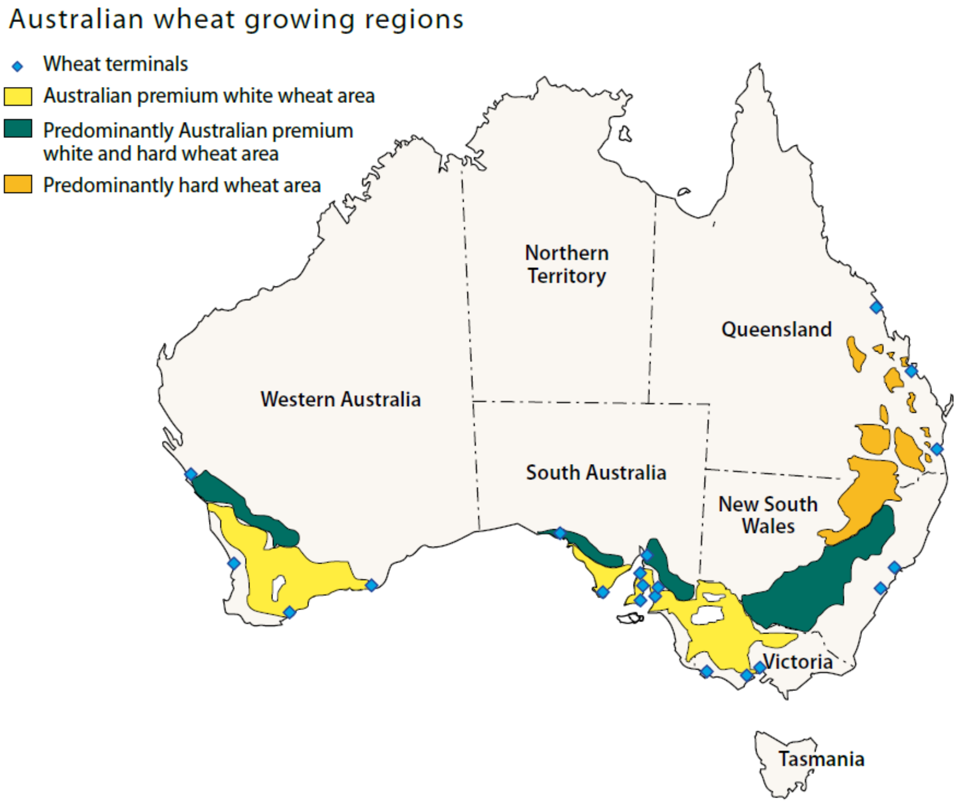


Figure 1. Principal premium white and hard wheat growing areas of Australia (ABARES 2011)

2.1 Regional analysis of dual purpose crop use – by Agronomist Interview

The following analysis in Table 3 summarises the feedback estimates provided by key agronomists and advisors interviewed in South-eastern Australian regions where dual purpose crop varieties are grown.

Table 3. Area of crops sown in South-eastern Australia and estimated area planted to dual purpose varieties 2010

Estimating the area sown and grazed of DPC varieties in key agricultural regions agronomically suited to these varieties.	Tasmania	Gippsland	South West Victoria	Western Slopes / Eastern Riverina NSW	Southern Tablelands	Total Region Estimates
Total area Sown to winter crops (ha)	34,000	10000	300000	740000	41000	1,125,000
Estimate of total area planted to **wheat** (ha)	14960	4200	102000	399600	14350	535110
Estimate of total area planted to **barley** (ha)	9860	2100	87000	81400	2050	182410
Estimate of total area planted to **canola**(ha)	2040	3000	69000	103600	4100	181740
Estimate of total area planted to **oats** (ha)	5100	400	36000	66600	14760	122860
Estimate of total area planted to **triticale** (ha)	2040	300	6000	88800	5740	102880
Estimate of area sown to dual purpose **wheat** varieties (ha)	13464	3150	20400	79920	11480	128414
Estimate of area sown to dual purpose **barley** varieties (ha)	493	105	4350	12210	1640	18798
Estimate of area sown to dual purpose **canola** varieties (ha)	0	0	0	1036	205	1241
Estimate of area sown to dual purpose **oats** varieties (ha)	2040	280	18000	59940	11808	92068
Estimate of area sown to dual purpose **triticales** varieties (ha)	408	150	2400	53280	3444	59682
Estimate of total area sown to DPC variety in all regions (ha)	16405	3685	45150	206386	28577	300203

The following observations are made about specific regions. It should be noted that in some sectors, crop grazing percentages may include crops that were ultimately sacrificial and used only for forage consumption.

2.1.1 Tasmania

- Approximately 34,000 ha currently planted to winter crops in Tasmania
- Dual purpose wheat varieties are highly adapted to Tasmania. Approximately 90% of the area planted (13,500 ha) to wheat in 2011 was planted to a dual purpose wheat varieties. The dual purpose wheat varieties are an integral component of the mixed farming systems employed by the majority of Tasmania's growers.
- The area planted to other dual purpose crops is relatively small with oats being the next biggest planting of approximately 2000 ha. Canola, due to limited marketing opportunities, is not grown widely in Tasmania.
- Dual purpose cropping systems are expected to continue to increase, especially with the current (2011) livestock prices and the expansion of the area being planted to poppies in Tasmania.

2.1.2 Gippsland

- Approximately 10,000 ha are currently planted to winter crops in Gippsland.
- Similarly to Tasmania the dual purpose wheat varieties are the major wheat varieties planted in this region with approximately 75% of the wheat area and

31% of the total area planted to crops being planted to a dual purpose wheat varieties.

- The area planted to other dual purpose crop varieties is relatively low and represents approximately 5% of the total area sown to crops in this region.
- The cropping area in Gippsland is projected to expand significantly in the next decade (Norwood 2009)

2.1.3 South West Victoria

- Approximately 300,000 ha is currently planted to winter crops in South West Victoria.
- Dual purpose crop varieties are strategically used for early planting and on wetter paddocks on the farm in this region. Grazing is conducted opportunistically (with no set pattern) depending on the seasonal conditions and soil types on which the crops are grown. Weed management / competition issues are a major obstacle to the use of dual purpose crop varieties in this region.
- Dual purpose wheat and oat varieties are the most commonly grown dual purpose crop varieties in this region. Approximately 20% (20,000 ha) of the area planted to wheat is planted to dual purpose wheat varieties. Approximately 50 % (18,000 ha) of the area planted to oats is planted to dual purpose oat varieties.
- The grazing of canola crops is of some interest to growers in this region but its use may be limited to due to uncertainty relating to withholding periods of pre and post emergent herbicides.
- The current excellent livestock price, in particular lamb prices, and the success of the Grain and Graze 1 project in this region has increased growers interest in grazing crops. If the seasonal conditions were favourable and stock numbers are available it is estimated approximately 20% of cropping area could be grazed.
- The availability of new pre emergent herbicides (eg., Bayer Crop Science product Sakura®) may increase the opportunity for greater areas of dual purpose crop varieties to be planted in this region.

2.1.4 Northern Victoria

- Due to the past decade of poor seasonal conditions and the limited availability of irrigation water the farming systems have changed dramatically in the north-east and irrigated region of Victoria. Agronomists / advisors spoken to in this region were hesitant to estimate the current areas planted to dual purpose crop varieties in this region.
- EGA Wedgetail, a milling wheat variety with some winter habit, is a popular variety for planting early and for grazing if the opportunity presents. A very small percentage of the area is planted to the true dual purpose crop varieties (*e.g.*, winter wheat by Ausgrainz (a company initially formed by an alliance between CSIRO Plant Industry and New Zealand's Plant & Food Research Crown Research Institute). Growers strategically graze crops of milling (wheat and oats) and malting (barley) quality grade grain varieties.
- Approximately 3% of wheat delivered to Graincorp south east Victorian region from the 2010/11 harvest was dual purpose crop varieties. The Graincorp south

east region of Victoria incorporates the regions traditionally referred to as the south west, central and north east cropping regions of Victoria.

- The strong livestock prices, favourable seasonal conditions and the increase in the availability of irrigation water will encourage growers to increase the area of crops planted to dual purpose grain in this region.
- Oats is grown for milling grain, hay and forage through central and north east Victoria. The majority of the varieties currently grown specifically for milling grain (e.g., Mitika, Yallara) or for hay (e.g., Wintaroo, Brusher) supply the domestic and export hay markets.
- Small areas of triticale are planted in North East Victoria
- Grain and Graze 1 has provided growers in this region with the confidence to graze their crops. However, grain and graze activity was severely reduced in this region over the last 10 years due to the poor seasonal conditions, lack of irrigation water and lower sheep numbers.
- When the Victorian Mallee and Wimmera are added to the north-east and irrigated region, approximately 20% of northern Victorian crops are grazed (GRDC 2011a). Fifteen per cent of those in southern Victoria are grazed (GRDC 2011b).

2.1.5 Western slopes and eastern Riverina regions of NSW (east of Newell Highway)

- Estimate of the total areas planted are wheat (400,000 ha), barley (80,000 ha), oats (70,000 ha), triticale (85,000 ha) and canola (105,000 ha) (NSW DPI 2010)
- In these regions, dual purpose crop varieties are estimated to be planted in the following areas: wheat (EGA Wedgetail type varieties) 80,000 ha, barley 12,000 ha, oats 60,000 ha, triticale 53,000 ha and canola 1,000 ha. In addition, Frank McCrae, ex NSW DPI, estimates 8,000 ha is planted annually to the Ausgrainz winter wheat varieties in the Coolah, Dunedoo, Spring Ridge districts
- Varieties suitable for dual purpose use have an alternative role in also being suitable for early sowing in this region. This is a market niche in its own right.
- In 2011 approximately 10-15% of canola crops in the higher rainfall regions (north-east of Wagga Wagga) were grazed. Key agronomists in this region believe the longer season spring type canola varieties will be the varieties of choice for grazing and grain production.
- Virtually no Ausgrainz / CSIRO winter wheats are grown in this area. The occurrence of Wheat Streak Mosaic Virus has discouraged growers planting the longer season winter wheat varieties.
- Approximately 10,000-15,000 ha is now planted to annually to Urambie dual purpose barley mainly in response to the occurrence of WSMV restricting wheat plantings.
- Approximately 6% of wheat delivered to Graincorp southern NSW region from the 2010/11 harvest was dual purpose crop varieties. This region is also a major feed grain use region and significant quantities of grain from dual purpose crop varieties can be expected to be stored and sold locally to major feed grain users or used on farm. Less than 2% of barley grain delivered to Graincorp southern NSW receival sites from the 2010/11 harvest were from dual purpose crop varieties.
- In recent years, the relatively low livestock numbers and high livestock prices have limited the potential of growers to be able to buy in animals to graze available crops. However, SeedNet, the commercialiser of EGA Wedgetail,

estimated that approximately 100,000 ha were being planted to this variety in the 2010/11 season. SeedNet was projecting the area sown to EGA Wedgetail to increase significantly in 2011 due to improved seasonal conditions, excellent livestock prices and growers having improved access to irrigation water.

- Two hundred and seventy delegates attended a Farmlink Research 'Mixed Farming Forum' held in August 2011. The large attendance is a strong gauge of the current grower interest in mixed farming / use of dual purpose crop varieties in this region.

2.1.6 Southern Tablelands NSW

- Estimated areas planted annually are: Wheat (14,000ha), Barley (2,000ha), Oats (15,000ha), Triticale (6,000ha) and Canola (4,000ha) annually in this region (NSW DPI 2010).
- If seasonal conditions were suitable and livestock numbers were available, the majority of the areas planted to wheat, oats and triticale would be grazed. Use of canola as a dual purpose crop is of interest in this region. Ausgrainz / CSIRO winter wheat varieties are used extensively through this region.
- Regional differences were evident in adoption of dual purpose crops surveyed in 2005 (Table 4). From a systems perspective, the tablelands terrain is predominantly hilly and is unsuitable for large-scale cropping; here, the main feed trough is in mid-late winter when pasture growth is constrained by cold temperatures, short days and foggy/cloudy weather. The small areas sown to forage or dual purpose crops are often referred to as *supplementary* areas available for livestock feeding but in fact they *substitute* for pasture. In contrast, on wheat-sheep farms on the arable Southern Slopes and Plains of NSW (and elsewhere), a large area (average 35%) of each farm is predetermined for cropping each year. Farmers acknowledge an operational advantage in spreading the workload of sowing crops over several weeks in autumn, and cereal crops with a winter habit are sought for this purpose. An area that is sown early (March-April) with suitable forage or dual purpose cereal cultivars *substitutes* for a grain cultivar sown later, and this area of forage/dual purpose crop *supplements* the pasture area available for livestock. Herbage produced during autumn is needed to meet a seasonal trough in the supply of green herbage that occurs on grain farms in late autumn (loss of crop stubbles, unreliable break of season) and/or early winter (slow regeneration of annual pastures).

Table 4. Percentage area of farms sown to Dual Purpose Crops, Southern NSW - 2005 Survey (Roberts 2011)

	All zones		Tablelands		Slopes		Plains	
Hectare	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
NIL	49	20%	1	3%	17	18%	31	27%
1_50	58	24%	23	68%	16	16%	19	17%
51_100	62	25%	8	24%	30	31%	24	21%
101_150	15	6%	2	6%	8	8%	5	4%
151_200	26	11%	0	0	10	10%	16	14%
201_250	6	2%	0	0	4	4%	2	2%
251_300	5	2%	0	0	1	1%	4	4%
301_350	2	1%	0	0	1	1%	1	1%
351_400	7	3%	0	0	5	5%	2	2%
401_450	0	0%	0	0	0	0%	0	0%
>450	14	6%	0	0	5	5%	9	8%

* # number of responses

2.1.7 Northern Tablelands / Queensland

- Forage cereals are used extensively on the northern tablelands NSW and Darling Downs region of Queensland.
- Small areas of dual purpose wheat varieties are planted on the Darling Downs and Central Queensland for their forage value only. No grain is harvested from these crops.

2.1.8 South Australia

- Area of crops grazed is 700,000 ha (Eyre Peninsula 80,000 ha), albeit grazing is more opportunistic than in NSW regions, with the farming system adapted to a drier, more variable environment.
- Crops in Mid-North of the state are perceived to have higher dry matter yield than regular pastures, with capacity to fill the autumn feed gap. About 40% of cereal growers still maintain a livestock enterprise, especially where they have "hill country". About 5% of barley growers are estimated to graze crops prior to later harvesting for grain. However, as some fences have been removed to allow use of larger cereal equipment, paddocks have become larger, and farmer may have insufficient livestock to apply adequate grazing pressure to the crop to ensure even grazing and maximum feed utilisation.
- With a significant hay export industry, South Australian farmers may harvest crops for export hay rather than grain, following earlier grazing.
- A post-grazing alternative to grain is harvesting for export hay.
- There is limited grazing of cereals and vetch in the Southern Mallee, but it is undertaken less frequently in Northern Mallee.
- Hybrid canola dry matter yield is much greater than forage brassicas, but some sales agronomists offering special forage crops are tending to discourage dual use crop grazing.

- The South Australian government moratorium on use of genetically modified crops prohibits farmers from having access to Round-up Ready® canola.
- In Eastern South Australia, only 2% of crops are grazed (GRDC 2011c)
- On Eyre Peninsula, where 5% of crops are grazed (GRDC 2011c), growers have concerns about the potential loss of crop yield.

2.1.9 Western Australia

- 600,000 ha crops are grazed, representing about 6% of WA crops being grazed (GRDC 2011e)
- Any grazing occurring is with locally preferred grain varieties – Eastern states dual purpose wheats, notably Wedgetail, are considered unsuitable in some WA areas
- WA growers have reservations about grazing cereals due to loss of crop competition with weeds due to preferential grazing of cereals
- A preference to graze Round-up Ready® canola rather than cereals is developing.
- Use of dual purpose crops is at an earlier stage of development than in the East, and is still seen as largely developmental as adaptations to local conditions are identified. Follow-up extension is likely to be required (Robinson 2011).
- A survey of the largest 50% of grain producers by production suggested that 20% of them had already tried grazing of crops, 30% were interested to know more, 15% were vaguely interested to know more and 35% were not interested at all.

2.1.10 Summary of regional analyses from agronomists

The following summarises the extent of regional use of Dual Purpose crops for grazing as advised through agronomist interviews:

- Dual purpose crop varieties were estimated to have totalled approximately 300,000 ha sown across the key dual purpose crop regions in 2011. Wheat is the major dual purpose crop sown (approximately 130,000 ha), followed by oats (approximately 90,000 ha) and triticale (approximately 60,000 ha). Dual purpose barley and canola varieties are planted in relatively small areas predominately on the western slopes / eastern Riverina region of NSW.
- Growers in Tasmania, Gippsland and Southern Tableland area of NSW regions rely significantly on the use of dual crop varieties in their farming systems. These combined regions represent an area of approximately 85,000 ha of winter crops. Wheat represented approximately 40% (33,000 ha) of the area sown annually and the Ausgrainz (CSIRO) winter wheat varieties are the dominate wheat varieties used in these regions.
- South West Victoria and South East South Australia growers, due to late breaks, issues with soil type, weeds and waterlogging will graze crops only when the opportunity presents. Approximately 20% of the area sown to wheat is planted to the longer season winter wheats annually. Grain and Graze 1 has given the growers confidence to graze any cereal crop if the opportunity presents. Grazing of canola crops may be limited again due to soil type, weed and waterlogging issues.

- Growers in northern Victoria irrigation/ high rainfall regions and the southern slopes / east Riverina regions of NSW are the major users, based on hectares planted, of dual purpose crop varieties. The EGA Wedgetail type wheats varieties are a key component of dual purpose crops in these regions. The major wheat breeding programs are aware of this market segment and are investing resources to breed improved varieties for this market segment. The HRZ wheat program has recently released a WSMV tolerant wheat variety with a milling classification which is suited to these regions. It is intermediate in maturity and thus not suited to early sowing.
- There is increasing interest in dual purpose crops in drier rainfall cropping areas.
- Dual purpose oats are the second most used dual purpose cereal species. Triticale was grown in relatively small area across most regions except for the Southern slopes of NSW. Grazing of canola crops was most prominent in the Southern slopes area of NSW.
- The grazing of canola was particularly popular on the southern slopes area of NSW in 2011. This practice is expected to grow as growers gain more confidence and improve their management skills. Key agronomists in this region believe the longer season spring type canolas will be preferred to dual purpose crop varieties.
- Grain and Graze projects have significantly improved growers understanding and management skills to maximise their returns from dual purpose cropping systems.
- The release of new pre emergent herbicides may increase the use of dual purpose crop varieties by overcoming weed issues in some regions.
- New fungicide seed and fertiliser treatments may limit grazing access to young crops and are further discussed in section 3.5, page 34.

2.2. The survey of growers and advisers

2.2.1 Grower and Adviser Response

Following discussions about information to be sought from the grower survey, a final design was agreed and 3857 invitations were despatched electronically on 23 July 2011 to 2694 growers and 1163 Advisers who were listed in the GRDC database, Details of the survey used are given at Annex 5. The survey was opened by 213 growers, of whom 207 returned the survey, while 186 advisers opened the survey and 163 returned a response. GRDC Agroecological Zones are shown in Figure 2. The distribution of survey forms and responses received are shown by GRDC Agro-ecological zones in Table 5.

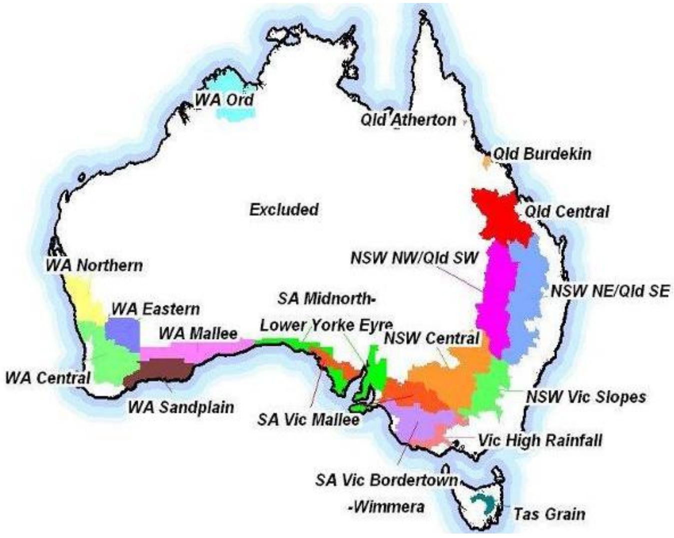


Figure 2 – GRDC Agroecological zones

Table 5 Distribution of survey forms and responses received by GRDC Agroecological zones

AEZ	Advisors Sent	Advisors Completed	Advisors % Completed	Growers Sent	Growers Completed	Growers % Completed
Excluded QLD	113	0	0.0%	90	2	2.2%
NSW Central	70	8	11.4%	146	6	4.1%
NSW NE/Qld SE	355	38	10.7%	505	30	5.9%
NSW NW/Qld SW	69	4	5.8%	149	6	4.0%
NSW Vic Slopes	209	36	17.2%	408	35	8.6%
Qld Central	31	2	6.5%	64	5	7.8%
SA Midnorth-Lower Yorke Eyre	132	14	10.6%	234	11	4.7%
SA Vic Bordertown-Wimmera	184	10	5.4%	350	29	8.3%
SA Vic Mallee	111	3	2.7%	166	10	6.0%
Tas Grain	3	0	0.0%	7	0	0.0%
Vic High Rainfall	57	4	7.0%	106	10	9.4%
WA Central	96	7	7.3%	242	25	10.3%
WA Eastern	9	0	0.0%	28	2	7.1%
WA Mallee and Sandplain	19	5	26.3%	79	8	10.1%
WA Northern	29	1	3.4%	83	4	4.8%
Excluded NSW	174	10	5.7%	130	11	8.5%
Excluded VIC	113	5	4.4%	76	4	5.3%
Excluded TAS	39	2	5.1%	31	1	3.2%
Excluded SA	74	5	6.8%	52	2	3.8%
Excluded WA	99	8	8.1%	99	4	4.0%
Excluded NT	7	0	0.0%	2	0	0.0%

It will be noted that 30 advisers' returns and 24 growers' returns are assigned outside of GRDC agroecological zones ("excluded state/territory"), representing those with capital city or regional addresses outside these zones. The distribution of surveys sent and returns completed is shown by national location on maps in Annex 6. Although there is some evidence of a higher level of responses from areas more likely to use dual purpose crops, suggesting a possible bias in responses, the panel concluded that the limited responses received made it impractical to draw any conclusions based on distributions by agroecological zones. The relatively low response rate of 8% from growers and 14% from advisers whose clients were sometimes in several agroecological zones limited the confidence that the panel had in drawing conclusions on even a GRDC northern / southern / western region basis or on farm size distribution basis. Most percentage data given has been expressed to the nearest 5%. Not all respondents completed full data sets. Data are presented in table 6 showing distribution of grower respondents. (Similar data are not presented for advisers due to diversity of clients)

Table 6. Distribution of grower respondents by GRDC region and farm size

Respondent distribution by GRDC Region	Growers with data		Respondent distribution by farm size (ha)	Growers with data
North	41		0 - 500	30
South	103		501 - 2000	76
West	39		> 2000	87

2.2.2. Crop Types Grazed

Sixty percent of growers in each of the three regions had grazed crops within the last three years. Ninety percent of advisers had clients who had done so in the northern and southern regions, but only 75 percent in the western region. Sixty percent of farmers with less than 500 ha had grazed crops. Fifty percent of those in the 500-2000 ha farm size range had grazed crops, while only 40 percent of those with more than 2000 ha had done so during the past three years.

The distribution of crop types grazed as recorded by advisers from estimates of grazing by their clients is shown in Figure 3. Dual purpose varieties constitute the majority of crops grazed.

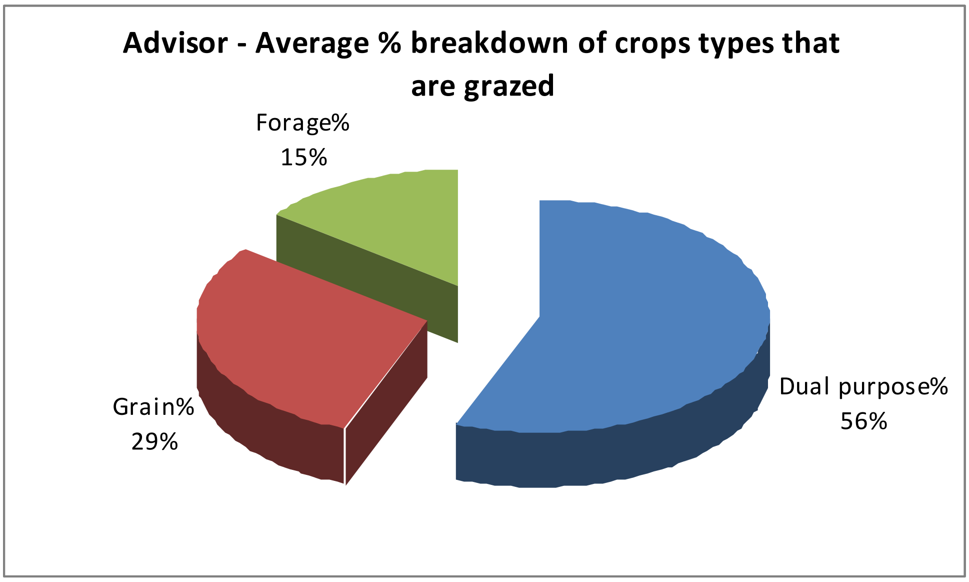


Figure 3: Mean proportions of crop types grazed by clients of advisers

2.2.3. Impact of property size

Figure 4 shows the distribution of crop types chosen by farmers for grazing according to property size. It would appear that dual purpose varieties are more widely used among small land-holders, possibly due to greater incentive to maximise property income due to limited land resources. Although there has been greater grazing of specialised grain varieties on larger properties, we do not have access to figures indicating what proportion of a total grain crop this might represent, nor how these varieties were grazed. Were they grazed during the vegetative phase and were subsequently harvested for grain or were they merely consumed as "failed crops" as a consequence of end-of-season drought conditions?

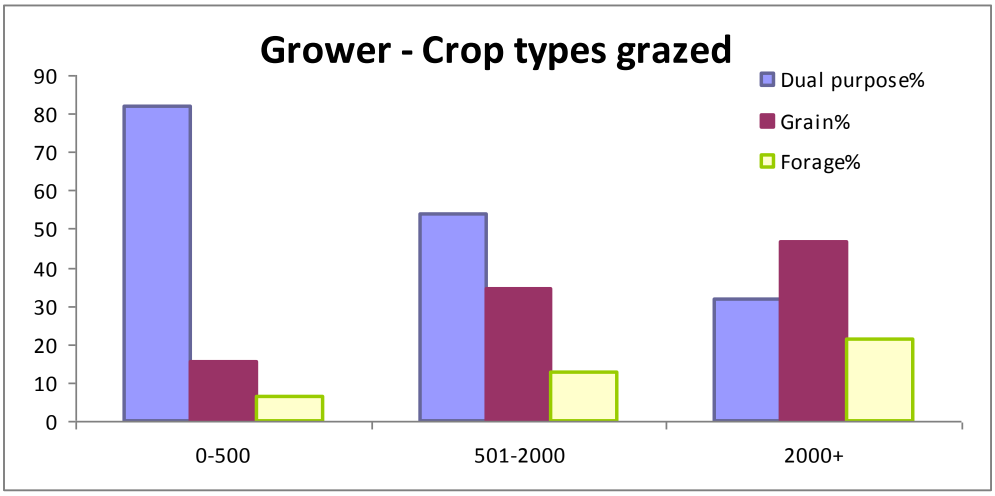


Figure 4: Crop variety types grazed according to farm size, 2008-2011

As farm sizes become larger, it has been suggested that there may be extra opportunities to delegate management responsibilities to individuals in the family, allocating them a specific enterprise to manage while still preserving the family partnership in mixed crop-livestock production across several properties. The complexity of managing large farms may also be offset through innovative business partnerships (leasing, sharing, syndicating, contracting) that achieve synergy on mixed or integrated farms, possibly by separating the ownership of crop and livestock enterprises and placing them into the hands of those with the necessary confidence and skills. However, it is evident from Figure 4 that as farm size becomes larger, interest in dual use varieties declines and interest in specific grain varieties increases. This may reflect the complexities of managing large grain-producing enterprises effectively, along with the difficulty of acquiring large numbers of livestock for grazing and hence lack of confidence to increase livestock production, potentially foregoing additional economic returns. Other issues could be agreater resilience to drought and price fluctuations and the necessity to husband capital for the large infrastructure required for extensive cropping.

2.2.4 Crop species grazed

A consideration of crop species that have been grazed (Figure 5) suggested that oats and wheat remain the primary grazing crops, with less use of barley. Whilst it has not been possible to analyse the significance levels between these crops, it is evident that there has been proportionately less grazing of canola compared to the conventional cereals, though there appears to be increasing interest in canola grazing. Triticale has some appeal on small properties, but appears of no significance on larger properties.

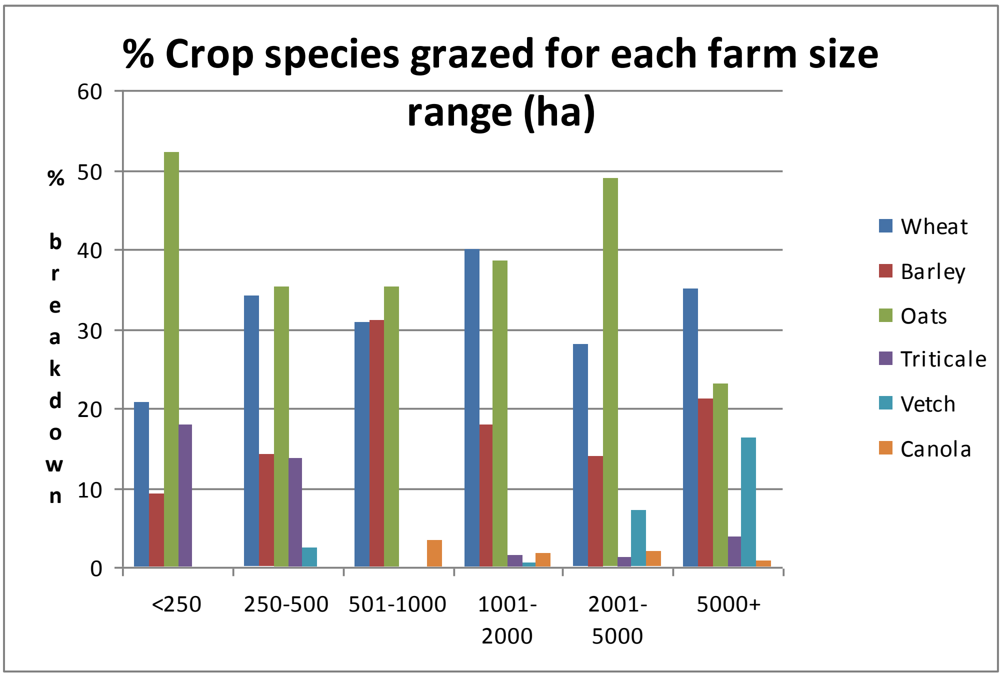


Figure 5: Percentage distribution of crop species chosen for grazing within each farm size category, 2008-2011

The current limited use of canola for grazing is reinforced by figure 6 which shows the proportion of crops grazed across the entire spectrum of respondents.

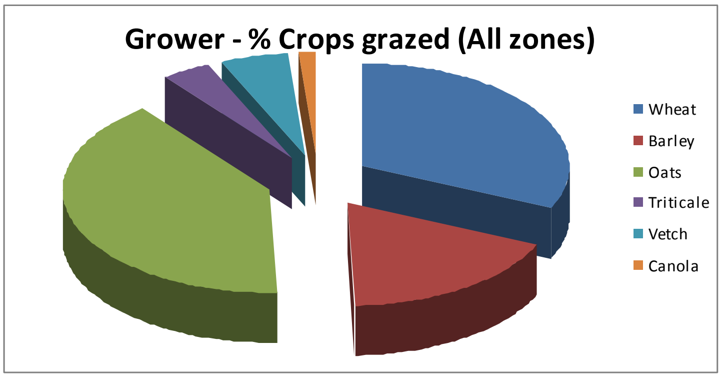


Figure 6 : Proportion of crop species grazed across all grower respondents

The proportionate distribution of crops chosen for grazing according to farm size is shown in Figure 7. Oats and wheat are the dominant crops, with triticale limited to small farms and use of canola again confirmed to be very low across all farm sizes.

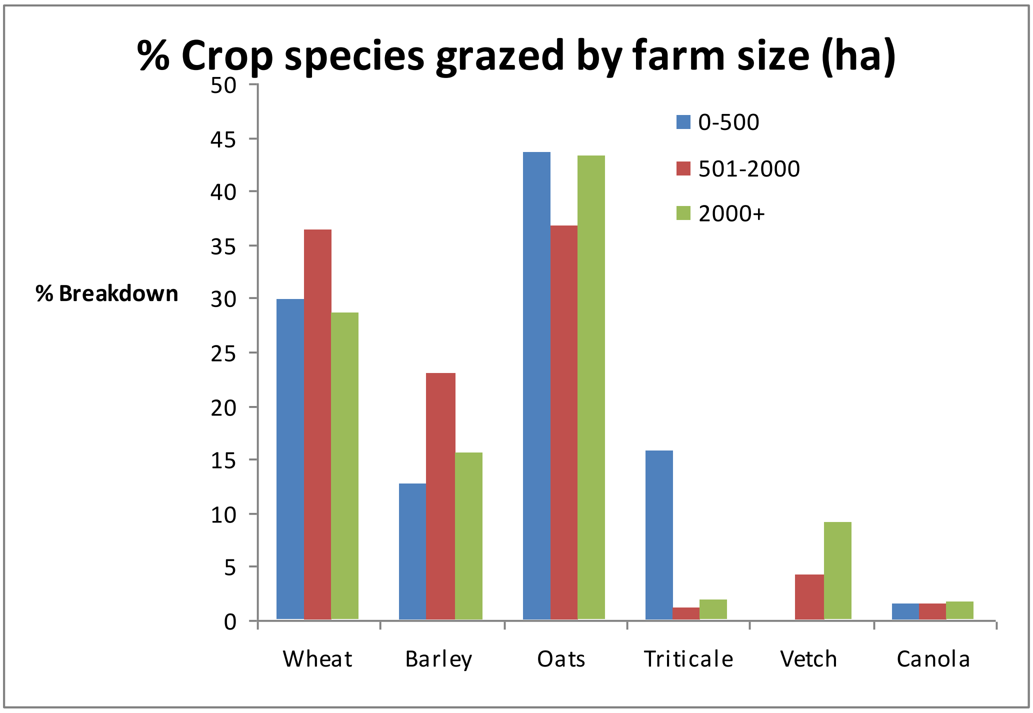


Figure 7: Distribution of grazing crop types across three size ranges of farms, 2008-2011

2.2.5. Distribution across GRDC Regions

It can be seen from Table 7 that West Australian growers and advisers are less inclined to use dual purpose varieties, probably because of the higher risk and shorter growing seasons experience in that state. Nevertheless, there is evidence of increasing interest in dual purpose crop use in the West.

Table 7. Choice of grazing crops (expressed to nearest 5%) by growers and advisers in GRDC regions

Variety type		Growers				Advisers		
		North	South	West		North	South	West
% of dual purpose varieties		50	55	30		40	55	25
% of grain yield varieties		30	30	60		20	35	55
% of forage yield varieties		20	15	10		40	10	20

Table 8 shows that most of the grazing undertaken was planned rather than opportunistic. Growers were inclined to ascribe a higher level of planned outcomes to their decision-making than was the case with advisers

Table 8. Percentage of planned and opportunistic grazing (expressed to nearest 5%) by growers and advisers in GRDC regions

Variety type		Growers				Advisers		
		North	South	West		North	South	West
% Grazing planned		80	80	75		70	50	75
% Grazing opportunistic		20	20	25		30	50	25

2.2.6. Deciding whether to graze

The decision to undertake crop grazing was predominantly driven by identifying the need for additional feed (45-60% of respondents), while the price of grain appeared to have little impact, representing about 5% of the influence on choosing to graze. Livestock husbandry considerations represented around 20% of grazing motivation in the North and South regions, but were of little importance in the West. The need to rest or re-establish pasture paddocks represented about 15% of decision-making among growers.

Western Australian growers were much more likely to harvest the grain from grazed crops for delivery for sale than those from other regions but the level harvested for use on the farm was approximately similar across all three regions, while northern growers had a higher propensity to continue grazing the crop (Table 9).

Table 9: Use by growers of crops after initial grazing undertaken (expressed to nearest 5%) in GRDC regions

Variety type	Growers		
	North	South	West
% harvested, grain for delivery	30	40	60
% harvested, grain for farm use	20	15	15
% cut for hay or silage	10	25	15
% continued for grazing	40	20	10

The major issue limiting the use of dual purpose crops by growers was fear of loss of grain yield (30-35% of respondents). Lack of confidence in integrating livestock grazing with cropping was commonly expressed, the more so by advisers in the West. Other reasons were lack of suitable varieties, particularly in WA and not needing the additional feed from crop grazing.

Northern and southern growers expressed stronger interest in investing in new dual varieties than did growers and advisers in the west, while western growers expressed more interest in extension of information on how to graze crops with developed guidelines and additional regional evaluation of dual purpose varieties. It was concluded that there is less appreciation and confidence in the use of dual purpose crops in the west than in the northern and southern regions.

Approximately 15% of respondents across all regions said that research funds would be better spent on other areas rather than on dual purpose crops.

3. A SYSTEMIC PERSPECTIVE OF DUAL PURPOSE CROPS, GRAIN YIELDS AND LIVESTOCK PRODUCTION

3.1 The national feedbase

The recent report on developing a National Feedbase Plan (Shovelton *et al.* 2011) prepared for Meat and Livestock Australia, prioritised ten existing technologies for research that would generate improvements in profitability and sustainability to the red meat industry. Better integration of crops with pastures came out as the sixth priority. However, dual purpose crop varieties have the potential to play a significant role in improving the performance of most of the other existing technologies highlighted in the National Feedbase Plan paper including; better pasture utilisation, improved grazing management, increased legume content, better integration of crops and pasture, improved control of weeds, increase use of fodder crops.

The report noted that not only had there been a shift to cropping in the traditional mixed cropping/livestock areas, but this had also occurred in the medium/high rainfall areas where there had previously been little cropping activity. This shift to cropping has important implications for research, development and extension (RD and E) and cross sectoral investment in the Feedbase Investment Plan, with the dual purpose crop varieties of increasing importance as a feedbase in high rainfall regions. As a result, a better understanding and managing pastures, livestock and cropping enterprises was a frequently nominated research theme with clear emphasis from the Temperate Slopes and Plains and lesser emphasis from the Temperate Highlands and the Wet Temperate Coast. The Program objective is to develop systems to improve integration of livestock, and the pastures that support them, with cropping enterprises. Primary attention needs to be given to the role of grazing cereals, legume break crops and the strategic use of containment feeding. The increased area used for cropping in combination with higher value of sheep and their products underpins the interest in ways to integrate these enterprises. Central to this interest is the role of pastures/crops, including legumes, as break crops for disease control and for high quality feeds, and the strategic use of containment feeding for meeting market specifications and managing the natural resource base. There is a clear recognition of a role for dual purpose crops as far as the red meat industry is concerned. There is strong case for MLA sharing more of the cost of developing dual purpose crop varieties with the GRDC.

It seems likely that there will be interest in dual purpose crops by at least some of those farmers also keeping cattle or sheep, the latter being increasingly oriented to meat production. Shovelton *et al.* (2011) have estimated the potential trends in the beef cattle herd and in sheep numbers in Southern Australia until 2015. Cattle numbers reduced a little after 2008 but are expected to slowly rise (Figure 8).

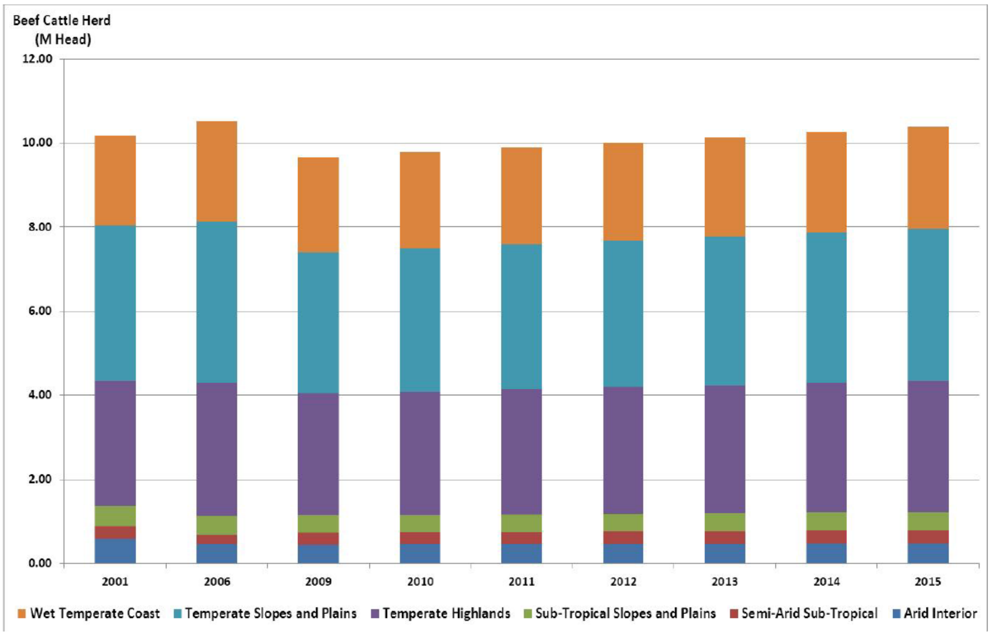


Figure 8 Projected beef cattle herd until 2015 (Shovelton *et al.* 2011)

The variation in the national sheep flock is much more apparent, with a substantial decline from 2001 to 2009. However, it may be noted that pasture and livestock value generated by enterprise type within agro-ecolgical zone for the years 2001, 2006 and 2009 increased despite a reduction in sheep and cattle numbers. One of the key drivers for this was the increase in the adoption and intensification within the traditional pasture regions of winter crops and the pasture benefit accruing to the crops (approx 30% of the value generated in Victoria and NSW was put down to the crop component). The shift away from sheep enterprises into alternatives such as cropping is expected to slow and unfavourable cropping experiences in the drought are beginning to encourage producers to return to increased sheep numbers. However, initial endeavours will be to increase breeding stock with little expansion in non-breeding adult sheep (wethers) even though wool prices have been strengthening. The overall anticipated trends in sheep numbers for Southern Australia are shown in Figure 9.

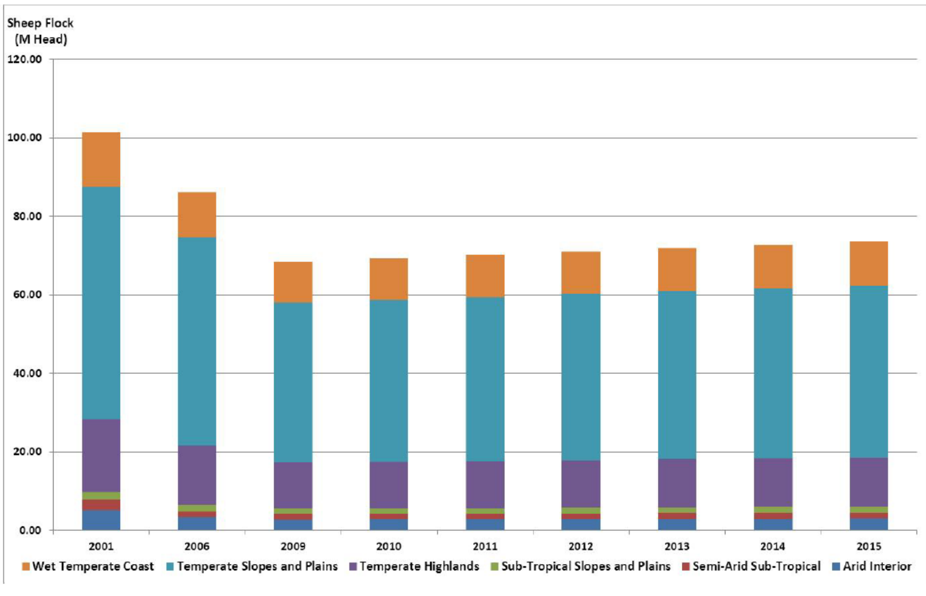


Figure 9. Projected sheep flock numbers in Southern Australia to 2015 (Shovelton *et al.* 2011)

The Grain & Graze 1 extension project has been very successful at improving growers' awareness of the opportunity to graze their crops and their management skills to maximise the profitability of both their livestock and cropping enterprises. The Grain and Graze 2 project will allow the benefits of Grain and Graze 1 to be developed and extended even further

A more detailed agro-geographical consideration of the cropping – livestock relationship follows.

3.2. Southern NSW and ACT – the principal region of use

In southern NSW, dual purpose cereals have been a popular component of farming systems in the high rainfall and wheat-sheep zones. Cereals have traditionally been used for dual purpose production (Spurway *et al.* 1974). From the statistics that have been collected on crop production, there is no way of extracting routine data on the area of crops grown for dual purpose uses, i.e. the important feed *and* grain category. Data on the areas of crops grazed for livestock production were available for 1972/73, when Hoogvliet and Wheeler (1977) surveyed a stratified random sample of producers located in the pastoral, wheat-sheep and high rainfall zones of Australia. At that time, feeding forage crops to livestock occurred on 43% of farms, a practice that was particularly popular in NSW (68% of farms) and Tasmania (60%) compared with Queensland (48%), Victoria (34%), SA (20%) and WA (37%). In the wheat-sheep zone, the practice was moderately popular – 57% of all wheat-sheep farms grazed livestock on crops and the actual area of grazed crops was 4.4% of the farm (6.2% in NSW). According to industry leaders in 2005, the area of dual purpose crops was less than about 200,000 ha in NSW and 400,000 ha (2% of the total area sown to cereals) in Australia. The Australian situation contrasts with that in the US Southern Great Plains region, where 30-80% of the 8M ha seeded annually to wheat is grazed in fall-winter (Pinchak *et al.* 1996, reported in Epplin *et al.* 2000).

The concept of dual purpose production from cereals on farms in the Australian wheat-sheep zone differs from the situation on predominantly non-arable farms in tableland districts such as Canberra. Considerable research into dual purpose production was undertaken during the 1970s. Livestock outputs and grain production from pasture-forage crop systems – type (a) in Figure 10 – were compared with pasture systems at Canberra (Axelsen *et al.* 1970; Dann *et al.* 1974; Dann *et al.* 1977; Dann *et al.* 1983), Benalla (Cannon 1974; Cannon *et al.* 1978) and Wagga (FitzGerald 1976). Typical of these comparisons was the comprehensive analyses conducted over 3 years (1965-68) at Canberra by Axelsen *et al.* (1970), who evaluated the costs and returns from farmlets that had either 0 or 33% of the area sown to an oats forage crop. The forage crop produced more herbage than a comparable area of pasture and, during the feeding period, livestock production on forage exceeded that on pasture. However, the gain during feeding barely covered the loss in sheep liveweight when sheep were confined to a smaller area while growing the crop; hence, there was no net advantage from the pasture + forage system. Axelsen *et al.* (1970) pointed out that an advantage could occur if a portion of the costs of the forage crop was offset by grain production. According to their analysis, a minimum of 1438 kg/ha was needed; in a one-year (1968) follow-up study, the oat grain yields were 2372 kg/ha (ungrazed), 2080 kg/ha (grazed in June) and 1442 kg/ha (grazed in June and August). In subsequent studies also at Canberra, Dann *et al.* (1974, 1977, 1983) reported improved sheep performance from pasture + oats farmlets compared with pasture-only farmlets but, even when grazed moderately, the oats yielded considerably less grain than when ungrazed. Dann *et al.* (1983) concluded that grazing oat crops in August rather than June or July gave the best combination of grazing days and grain production from dual purpose crops sown in March-April, and produced the best economic return based on prices available for lamb and grain/hay at the time.

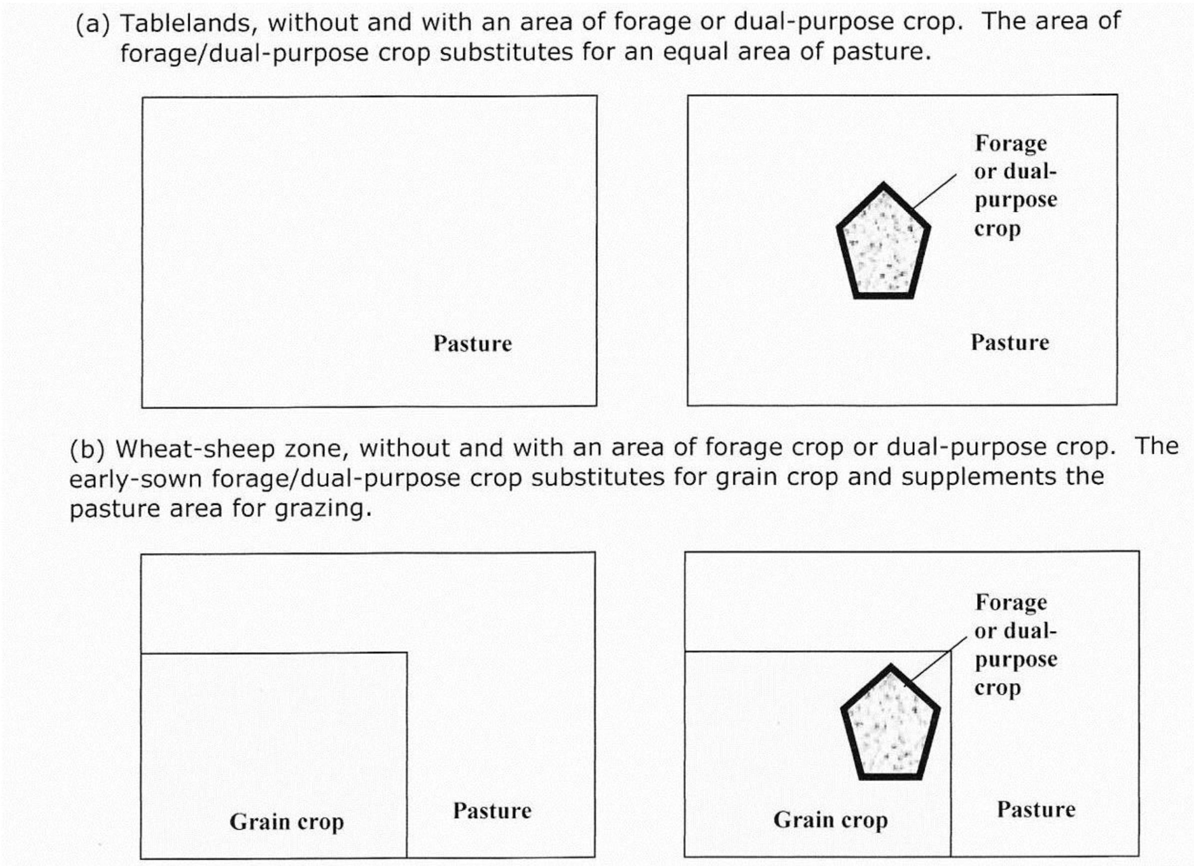


Figure 10: A diagrammatic representation of hypothetical farm systems in the high-rainfall zone (NSW Tablelands) and the wheat-sheep zone (NSW Slopes and Plains)

From 1973 to 1999, a series of investigations were undertaken with dual purpose cereals at Temora, a site that is representative of farming systems in the wheat belt (Figure 1b) (Wolfe et al. unpublished manuscript). At the time, sound information was available on the agronomic management of cereal crops for forage (Southwood *et al.* 1974, Spurway *et al.* 1976) but the effects of (1) cereal forage on sheep production and (2) grazing intensity and duration on grain production were unquantified for these conditions. Furthermore, there was interest in the potential for livestock and grain production from dual purpose cultivars of cereals other than oats, particularly wheat.

Overall, the results from the Temora work, were:

- There was little difference between cereal species or cultivars in their ability to produce early feed; early sowing time, a high seeding rate at sowing and post-sowing climatic conditions were the more important factors to early dry matter accumulation. Grazing could commence as soon as the plant root systems were sufficiently well developed to provide adequate anchorage when grazed. A target of 1000 kg/ha of green dry matter prior to grazing was desirable, especially for pasturing livestock at moderate sheep stocking rates (e.g. 20 sheep/ha or 2 yearling cattle/ha) for several weeks. A range of commencing grazing dates was found in a 2005 survey conducted in Southern New South Wales Figure 11.

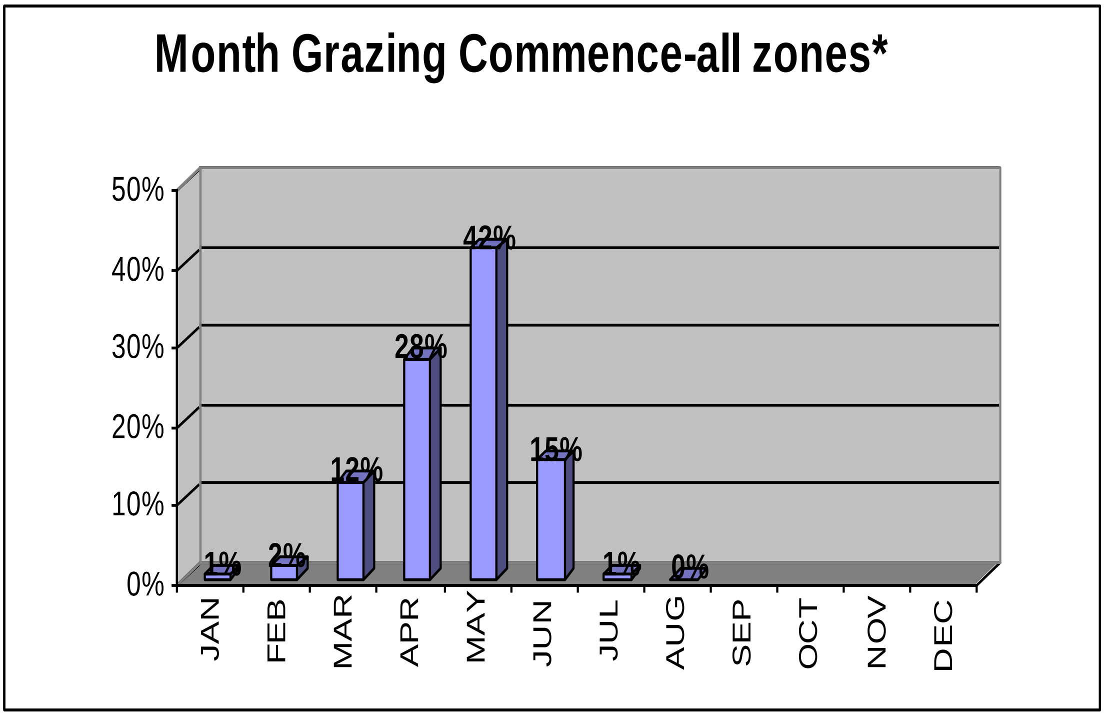


Figure 11: Month grazing – date of commencement, Southern NSW – 2005 survey (Roberts 2011)

- In most years, the amounts of grazing provided by oats, barley or wheat were sufficient to produce weekly liveweight gains for 20-30 dry sheep/ha grazed continuously on crop for 4-6 weeks – longer in favourable years when extra feed was not so important and less in drought years. However, these experiments were conducted during decades when the climate was relatively favourable, there being at least one moderate rainfall event in autumn plus a reasonable level of soil moisture was available in winter-spring for regrowth and grain fill. These favourable conditions were less evident during the decade ending in 2010.
- The ability to graze livestock on supplementary areas of dual purpose crops has quite a sizeable impact on the winter stocking rates of sheep on the pasture component of the farm (Table 10).

Table 10. The potential impact of dual purpose crops on pasture stocking rates (PSR) in winter on hypothetical farms in the wheat-sheep belt.

Hypothetical* 1000 ha farms		#1	#2	#3	#4	#5
Area of all winter crops (ha)		200	300	400	500	600
Area of pasture (ha)		800	700	600	500	400
Total no. of sheep		8000	7000	6000	5000	4000
		During grazing, the calculated early-mid winter PSR (sheep/ha)				
	0%	*10.0*	*10.0*	*10.0*	*10.0*	*10.0*
Area of dual purpose crop (%	10%	*9.5*	*9.1*	*8.7*	*8.0*	*7.0*
of cropped area	20%	*9.0*	*8.3*	*7.3*	*6.0*	*4.0*
	30%	*8.5*	*7.2*	*6.0*	*4.0*	*1.0*

* Assumed carrying capacities are 10 sheep/ha/year on pasture and 20 sheep/ha while grazing a dual purpose crop from early to mid-winter.

- For true dual purpose cereal cultivars sown in March-April, grazing for several weeks until mid-July either slightly increased or had little effect on grain yield in five years (1973, 1977, 1980, 1981, 1999), and moderately depressed grain yield in three years including one with a favourable growing season (1974) and 2 affected by an autumn-winter drought (1975, 1976).
- Yield depressions, when they occurred, appeared to be a consequence of loss of tillers/m^2 rather than less grains per ear or weight per grain. For grain recovery, a 'winter habit' was essential to prevent the growing point in each cereal tiller elongating above ground level before mid-July.
- Dual purpose oat cultivars from the Temora program had an improving but considerably lower grain yield potential than dual purpose wheat and triticale cultivars or grain-only oat cultivars. A further problem recognised with oats is the low whole-grain digestibility, due to a high lignin content of the oat husk and seedcoat (Rowe and Crosbie 1988), of many high-yielding or processing quality grain cultivars (e.g. Echidna, Mortlock, Possum, Yallara) (Matthews and McCaffery 2011).
- 'Crash grazing' (grazing for a few days with up to 1000 sheep/ha) increased the selection pressure against those genotypes with a weak winter habit and, with safeguards against excessive grazing or trampling, it is suitable for use in selection nurseries.

It was concluded from these experiments that, at least in the wheat belt of southern NSW, the on-farm production targets required for dual purpose crops are 1000 kg/ha of green dry matter by late May, a grazing duration of 6 weeks at 20-30 dry sheep/ha during the period from late May until mid-July, and grain yields that are comparable with grain-only cultivars sown at their normal time. Breeders of dual purpose cereals must continue to place most emphasis on selecting for the winter habit, disease restsitance and a high yield of quality grain rather than for forage production.

Virgona et al. (2006) and McMullen and Virgona (2009) reported recent experiments on the effect of grazing/defoliation on dry matter production and grain recovery of dual purpose wheat cultivars. The impact of grazing was either positive or slightly negative, depending on for how long the grazing period was extended into July-August (early stem elongation). Comparing the grain yield of grazed vs. ungrazed crops, a positive effect on grain yield occurred from the combined effects of less lodging, a conservation of soil water from winter for the grain fill period, and a fortuitous coincidence of delayed development (a delay in anthesis and maturity of about 1 day for every 4-5 days of grazing) with later rain (Virgona et al. 2006). Grain yield reductions occurred if grazing impinged on or coincided with the onset of stem elongation (Zadok's growth stage 31). Minor effects of grazing on grain yield also occurred in the experiments of McMullen and Virgona (2009), and further, the grain yield of the best dual purpose wheat cultivar(s) (sown in mid-late autumn)was equivalent to that of a contemporary spring wheat cultivar sown several weeks later.

Recent research with winter and spring genotypes of canola evaluated for a dual purpose role in the Canberra environment (Kirkegaard et al. 2008) mirror the work with cereals at Temora and Wagga quite closely, once allowance is made for the slower rate of crop development in the cooler tablelands environment. Winter canola varieties sown from early March to mid-April produced 2.5–5.0 t/ha of biomass providing 0.3–3.5 t/ha of high-quality forage grazed by sheep in winter. The spring varieties produced similar amounts of vegetative biomass from April sowing but were unsuited to the earlier March sowing as they flowered in early winter and did not recover from grazing. The canola forage was readily eaten by sheep; alkane-based estimates of diet composition indicated that >85% of the organic matter intake consisted of canola. Canola forage was also highly digestible (86–88%) and Merino hoggets grew at 210 g/day from a dry matter intake of 1530 g DM/day. The canola generally recovered well when grazed in winter before bud elongation. Delays in flowering associated with heavy grazing ranged from 0 to 4 days when grazed before buds were visible, to 28 days if the crop had commenced flowering. Significant delays in flowering (>14 days) associated with winter grazing did not reduce seed yield or oil content when favourable spring conditions allowed compensatory growth. Yield loss was observed when winter and spring conditions were unfavourable for compensatory growth, or if grazing continued too late into spring (late September) irrespective of seasonal conditions. The yield loss was more than offset by the value of the grazed forage.

3.3. The potential for dual purpose crops in other areas of Australia

Traditionally, dual purpose crops have been grown in NSW, eastern Victoria and Tasmania. This popularity presumably reflects not only the opportunities available for early sowing on these crops based on the likelihood of autumn rainfall but also the local availability of suitable winter-habit cereal cultivars. The Temora program was the only breeding program that specifically targeted dual purpose cultivars of oats, and dual purpose wheat breeding was also a feature of wheat breeding programs at Temora and Wagga (Penrose et al. 2003).

A crude comparison of the opportunities available for early sowing, based on P/E ratios, is shown in Table 11. This table explains, at least in part, why the practice of early sowing with dual purpose cultivars has been more popular in NSW, NE Victoria and Tasmania than in western Victoria, SA or WA. The region by region popularity of pastures and sheep is another factor. There is traditionally lower incidence of sheep on Queensland mixed farms, an inability to appreciate the opportunity and realise it or perhaps a level of apathy of Mallee mixed farmers towards sheep (Robertson and Wimalasuriya 2004) and a scarcity of good-quality farm labour especially in Queensland and WA because of the mining boom). The sheep component of mixed farming understandably suffers from the pressure on farmers to simplify their enterprise mix in response to the drive towards larger scale and to achieve a satisfactory lifestyle in isolated rural communities (e.g., WA, where after harvest many farmers like to spend most of the summer on the coast). Results from the GRDC Dual Use crops survey suggest that growers with larger farms and Western Australian farmers have been less likely to engage in crop grazing to support livestock enterprises, despite the probability that the bigger farm sizes could more profitably do so.

Table 11. Opportunities for the early sowing of dual purpose cereal cultivars.

Month	Feb	Mar	Apr	May	June	DP cultivars useful?
Location						
Wellington NSW	0.23	0.19	**0.25**	**0.57**	**0.75**	Yes
Temora NSW	0.14	0.13	**0.27**	**0.66**	**0.91**	Yes
Condobolin NSW	0.12	0.12	0.14	**0.38**	**0.51**	Marginal
Cressy Tas	0.19	**0.28**	**0.61**	**1.40**	**2.10**	Yes
Tatura Vic	0.09	0.16	**0.34**	**0.91**	**1.20**	Yes
Walpeup Vic	0.06	0.05	0.12	**0.39**	**0.60**	No
Turretfield SA	0.04	0.06	**0.22**	**0.65**	**1.18**	Yes
Minnipa SA	0.03	0.03	0.09	**0.56**	**0.31**	No
Northam WA	0.02	0.04	0.15	**0.82**	**0.84**	No
Merredin WA	0.02	0.05	0.11	**0.41**	**0.82**	No

Notes: The values in the table are the ratio of precipitation (P = median monthly rainfall) to evaporation (E = potential monthly evaporation), for selected stations maintained by the Australian Bureau of Meteorology, accessed at http://www.bom.gov.au/climate/averages/ on 24th July 2005. It is assumed that this ratio must exceed 0.2 (P/E >0.2) for there to be an opportunity to establish cereals successfully, and these months are shown in bold type.

3.4. Livestock aspects of utilising dual purpose crops

Grasses other than cereals have a long history of use as forages, and there are brassica species specifically bred for forage use, so in a sense most cereals and seed-brassica species can all be regarded as 'potentially dual purpose'. However, describing current crop species in these terms overlooks the livestock management issues that dual purpose cropping generates. The history of dual purpose cropping during the 20th and early 21st centuries makes very clear the extent to which actual dual purpose crop use has fallen well short of potential.

Forage oats has long been a component of Australian grazing systems, but ultimately, its contribution to farm incomes was restricted by the low prices for oat grain. Grazing of wheat crops and its effect on grain yield were well researched in the first half of the 20th century, but interest in dual purpose cropping diminished with the development of shorter-season and semi-dwarf varieties (see Pugsley 1983). These varieties were developed to address valid agronomic objectives (e.g. reduced lodging), but their shorter-season characteristics meant that the 'window' in which they could be grazed without dramatically reducing yield of this higher-value grain was short in duration and hard to manage (see Harrison *et al.* 2011 for further discussion). Livestock-management requirements for wheat grazing were well studied in Australia in the 1960s-1980s (e.g. Dann *et al.* 1977) and demonstrated that unless livestock were removed at 'the right time', grain yield could be substantially reduced. The uptake of the practice by producers was restricted by the high degree of managerial input needed for success, especially in relation to this key aspect of the timing of livestock removal from the crop. It is worth noting in passing that another major component of this phase of research in Australia was work on the utilisation by livestock of crop stubbles (e.g. Coombe and Mulholland 1983). This is not a major component of current dual purpose cropping work, despite the high stubble loads generated by modern winter wheats.

The 'quantum jump' in the utilisation of wheat crops for forage came with the development in the late 20th century of wheat varieties with true long-season

characteristics including, crucially, the need for winter vernalisation before flowering would occur (see Davidson *et al.* 1990). The need for vernalisation meant that crops could be grazed safely, in the knowledge that they would not flower until they had received their requisite period of winter cold. This, coupled with the development of the National Grain & Graze Program brought about major changes in the viability and adoption of dual purpose cropping in Australia (see Price and Hacker 2009).
The livestock and grazing management issues discussed below are derived mainly from the research work supported by GRDC either directly or via the Grain & Graze program, and relate exclusively to the utilisation of long-season or true winter cereals or brassicas.

3.5. The grazing of dual purpose wheat: grazing management issues

The grazing management issues arising from a decision to graze a wheat crop can be dissected into the following:

3.5.1. What wheat to sow?

Ultimately, the decision of which cereal to use is an agronomic one but under current grain prices, the higher value of wheat grain favours the use of dual purpose wheat with which there has been extensive research in the last decade (see Dove *et al.* 2011; Harrison *et al.* 2011). Similarly, the choice of which wheat cultivar to use is also an agronomic decision though clearly, long-season or true winter types will be a more flexible fit into the dual purpose system (see McMullen and Virgona 2009). In some circumstances, livestock show no grazing preference for any one winter wheat over another (Dove and McMullen 2009) although there is anecdotal evidence that stock may dislike red wheats. Once a choice of cereal is made, there are a number of key points to ensure best-bet grazing management of a system based on a dual purpose cereal.

3.5.2. When to sow?

The crop should be sown early (March if possible) with a long-season or true winter variety. Experience in SE Australia over the last decade has shown that early-sown wheat can be exposed to greater risk of wheat-streak mosaic virus (WSMV), due to the presence over summer of green material capable of being an alternative host for the wheat curl mite (the WSMV vector). In SE NSW in 2005, extensive outbreaks of WSMV in grazed crops resulted in a widely-held view amongst producers that grazing itself was the prime cause of increased WSMV infection, and dual purpose wheat sowings were reduced as a consequence. However, early evidence from the USA (Sill *et al.* 1954) coupled with more recent gene-technology based research in Australia (Muhammad *et al.* 2010) has shown that increased WSMV incidence is not due to the grazing process itself and is more likely related to crop/weed hygiene over the preceding summer. Strict attention to this, or sowing the wheat after canola, will reduce the risk of WSMV.

3.5.3. When to graze, and with what?

In relation to the commencement of grazing, data from both the USA (e.g. Zhang 2011) and Australia (e.g. Dove *et al.* 2011) indicate that grazing by either sheep or cattle can start as soon as cereal plants are well anchored (the 'tug test') and when the amount of forage exceeds 1-1.5 t DM/ha. However, in relation to the time of grazing, it should be noted that some seed sources are being protected with Jockey® which contains the active ingredients fluquinconazole and prochloraz and has contact and systemic activity against a range of fungal diseases, especially take-all and early foliar diseases, in wheat, barley and blackleg in canola. Being systemic, Jockey® not only protects the seed but also extends into the leaves and roots of young plants, protecting the roots by both directly killing the fungus and enhancing the roots' natural defences. Treated crops must not be grazed by livestock or cut for stock feed within six weeks of sowing, or grazed by dairy cows producing milk for human consumption within 12 weeks of sowing.

The decision about when to start grazing is much less important than the decision about when to stop. Studies on wheat grazing in the Great Plains of the USA have primarily been with cattle (see Zhang 2011) and the data produced can probably be applied to Australian conditions, where much more of the work has been with sheep grazing. A feature of the sheep-grazing work done in Australia is that it has been substantially conducted with young growing sheep. Much less work has been done with ewe/lamb systems, and putting ewes with lambs onto grazed cereals is not common. However, the value of increased forage in winter could be greater for pregnant or lactating ewes and could allow a re-think of lambing times (see below). Research is required to establish whether this is a sound proposition.

3.5.4. What stocking rate to use?

In relation to the choice of stocking rate for cereal grazing, very low short-term stocking rates on the crop (e.g. 10 DSE/ha) result in good liveweight gains because there is so much available forage, but they are uneconomic because they make sub-optimal use of the cereal forage. At somewhat higher stocking rates (e.g. 15-20 DSE/ha), 'patch grazing' can develop in which livestock overgraze patches of the cereal, while the rest of the crop continues to grow and becomes less preferred by stock. Perhaps counter-intuitively, this grazing behaviour can lead in turn to lower liveweight gains than occur at either lower or higher stocking rates, because the effective grazing pressure on the patches is very high (Dove 2007). A useful rule-of-thumb is to graze cereals with about 1000 kg of live animal/ha (e.g. 33 sheep/ha each weighing 30 kg or 3 beasts/ha each weighing 333 kg); experience in southern Australia is that this results in about a month's grazing before the wheat reaches a critical point for the removal of animals, though this time will be determined by the area available and the number of stock on hand for dual purpose grazing. If a smaller stocking rate is used, say 700 kg of live animals per ha, six weeks of grazing may be possible, but care must be taken to get the stock off prior to stem elongation.

Provided livestock are removed before a critical crop growth stage (see below) it is likely that over a wide range of stocking rates, there may be little effect of the grazing on ultimate grain yield (see Dove *et al.* 2011; Zhang 2011). In the 5 seasons shown in Figure 12, the number of sheep grazing days/ha obtained from crop grazing ranged from 1500 in an excellent spring (2005), when there was almost no effect of grazing on grain yield, down to 1000 in a dry season (2006). However, it was notable that in this dry year, although grain yields were low (1-2 t/ha), grain yield was actually higher after grazing for a month by 18 hoggets/ha and even at 33 hoggets/ha, grain yield was the same as the ungrazed crop (i.e. 1000 grazing days/ha were obtained 'for free', in terms of grain yield). If it becomes necessary to reduce the stocking rate in the cold winter months from July to mid August, an alternative feed source will be required.

Increases in grain yield after grazing have now been observed on a number of occasions and have been attributed to reduced water use by the grazed crop in winter and conservation of soil water through to the grain ripening stage (Virgona *et al.* 2006; Kelman and Dove 2009; Harrison *et al.* 2010).

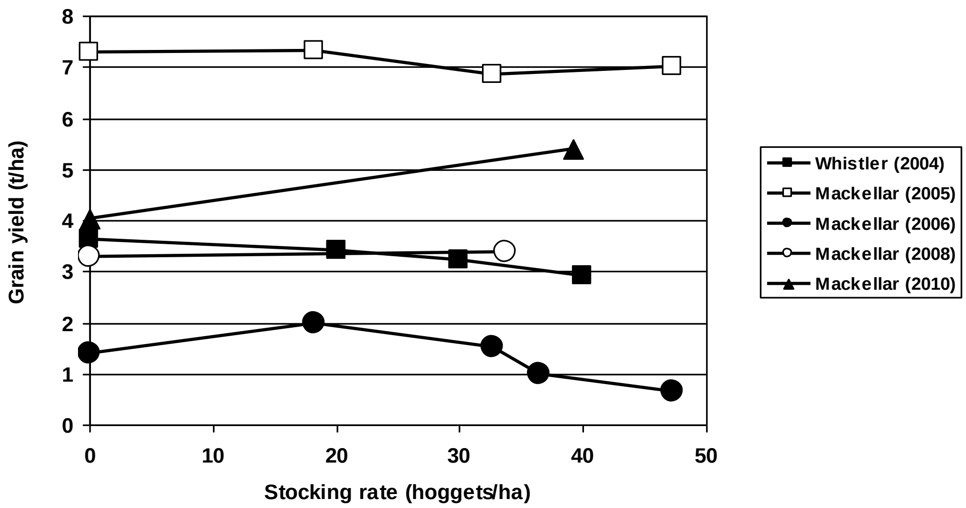


Figure 12. Effect of grazing dual purpose wheats at a range of stocking rates (number of 30 kg Merino hoggets/ha) on the ultimate grain yield of the crop (t/ha) (Dove et al. 2011), for either Whistler or Mackellar wheats.

3.5.5. *When to finish grazing?*

The decision about when to remove stock is much more important than the choice of stocking rate. Provided animals are removed before the crop reaches Zadok's growth stage 31 (stem elongation, one node visible – Figure 13), grazing effects on yield should be minimal (see Zhang 2011; Harrison *et al.* 2011).

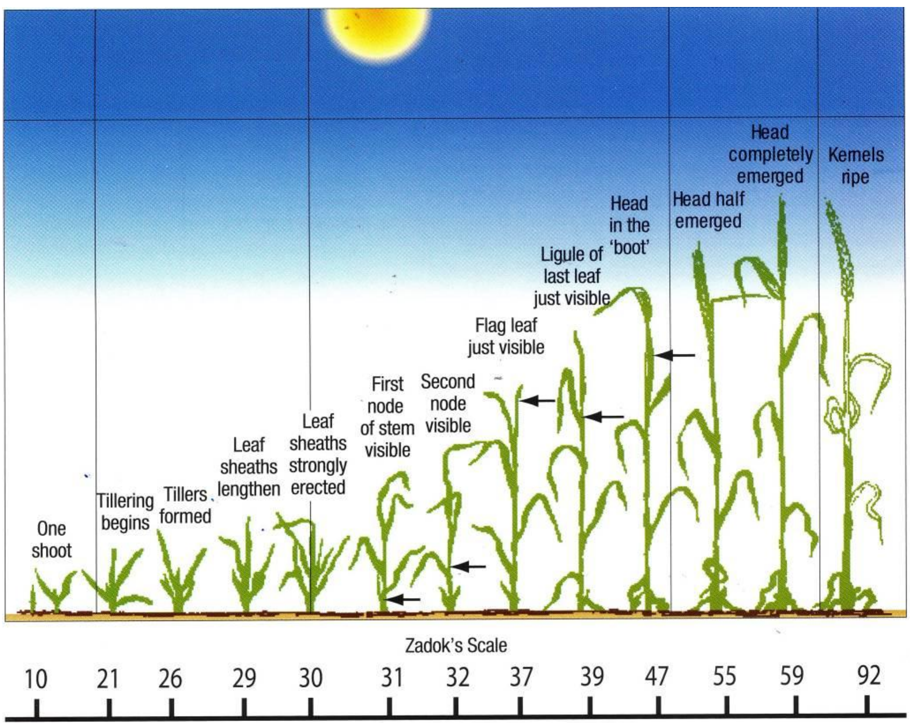


Figure 13: Zadok's growth stage scale (GRDC Dual Purpose fact sheet 7-09)

A useful management tool is to place small 'exclusion cages' within the crop, which prevent animals from grazing within the cage. When the growth stage of the crop inside the cage reaches 31, the grazed material will be slightly less developed (e.g. growth stage 30), because grazing tends to delay crop development (e.g. McMullen *et al.* 2006; Virgona *et al*. 2006; Kelman and Dove 2009), and stock can be removed knowing that growth stage 31 has not been achieved.

The relative effects of stocking rate cf. length of grazing are apparent in the data in Table 12, constructed from the GRDC-funded work of McMullen *et al.* (2006). With shorter grazing periods of 21-28 days, a near doubling of stocking rate had no significant effect on grain yield. By contrast, extending the grazing period significantly reduced grain yield, especially at the higher stocking rate. In a systems sense, whether or not the grain yield reduction represents a net economic loss will depend on the relative prices of wheat grain and animal liveweight gain, since the higher stocking rates and longer grazing periods also resulted in more sheep grazing days/ha. The mechanism of the above yield loss was shown to be related in part to greater consumption by sheep of developing wheat ears when the grazing period was extended (McMullen *et al.* 2006). To a large extent, GRDC investment in work such as this has resolved most grazing management issues for sheep grazing winter wheat. Less is known in relation to cattle grazing and although winter wheats are grazed by cattle in the USA, their data are less relevant to Australian conditions because the backgrounding of cattle on wheat pasture tends to be for longer periods and at lower stocking rates than is practised in Australia.

Table 12. Effects of stocking rate and length of grazing period on the grain yield and sheep grazing days/ha achieved at two sites in NSW (grain yields followed by different letters differ significantly $P<0.05$). (from McMullen *et al*. 2006)

Site	Stocking rate (DSE/ha)	Grazing period (days)	Grain yield (t/ha)	DSE grazing days/ha
Cookardinia	17	21	5.8a	365
	29	21	5.8a	599
	17	41	5.4b	713
	29	41	5.0c	1169
Wallendbeen	17	28	3.8a	465
	31	28	3.9a	855
	18	43	3.1b	757
	33	43	2.3c	1412

3.5.6. Are there management options other than grain+grazing?

A feature of much of the Australian research on dual purpose cropping systems is that livestock utilisation of the crop is via winter grazing. This is only one of a range of options available to producers to increase income from a dual purpose cropping system. Other available options, all of them season-dependent, are high-quality cereal hay production (including hay for export), silage production (e.g. for sale into dairy systems) and sacrificial grazing (i.e. grazing with no intent to harvest any grain crop). These options have received less attention by Australian researchers, though Bell *et al.* (2009) investigated sacrificial grazing in a simulation study, and suggested that this option was a major opportunity to increase profitability, especially in the face of increased climate variability.

3.5.7. How much effect does grazing have on grain yield?

Both positive and negative effects of winter grazing on grain yield of dual purpose wheats are evident in the data in Table 1 and Figure 1; Harrison *et al.* (2011) have extensively reviewed literature reports of grazing effects on grain yield. In general, their survey confirms that grain yields tend to decrease with longer grazing durations and later dates of grazing, with the grain yield penalty being greater if grazing extends beyond stem elongation or the appearance of first hollow stem (Zadok's stage 31). Over the 34 studies cited by Harrison *et al.* (2011), the effect of grazing by sheep or cattle (or the effect of clipping to simulate grazing) ranged from a 36% reduction in yield to a 75% increase in yield (following clipping). Overall, the mean effect of defoliation was a yield reduction of 7% (standard deviation 25%). An important point to note is that of the 34 studies, 15 reported positive effects of grazing on grain yield. As Harrison *et al.* (2011) emphasise, the mechanisms underpinning grazing effects on grain yield are not simple and difficult to predict in advance. However it is clear that a major component of the effect relates to the balance between the effects of grazing on delayed crop phenology and reduced leaf area index and the transient increase in photosynthesis which occurs in grazed crops (Harrison *et al.* 2010).

3.5.8. The mineral nutrition of livestock grazing dual purpose crops

A significant component of GRDC investment in dual purpose cropping systems in SE Australia has been related to the mineral nutrition of livestock grazing such crops. The stimulus for this work was the concern in Australia about the variability in liveweight gain of livestock grazing winter wheat, coupled with the known responses to Mg supplementation in cattle grazing winter wheat in the USA (Dove 2007). A survey of the mineral content of dual purpose cereals in Australia demonstrated that winter wheats were marginal for Mg content, relative to the daily requirements of growing livestock. Based on this, supplementary Mg (Causmag; MgO) was offered to crossbred lambs grazing Wedgetail wheat and led to a 54% increase in liveweight gain (Dove and McMullen 2009). In order to improve the palatability of the supplement, it also included common salt; subsequent work has demonstrated that the observed liveweight gain response was in fact a response to both Mg and Na, as the data in Table 13 demonstrate.

Table 13. Effect of Mg and/or Na supplementation on sheep and cattle liveweight gains grazing dual purpose wheat

Livestock species	Supplement (no. of experiments)	Increase in liveweight gain cf. no supplement
Sheep*	Mg (2)	24%, 25%
	Na (3)	18%, 25%, 37%
	Mg+Na (2)	31%, 54%
Cattle*	Mg (1)	14%
	Na (1)	23%
	Mg+Na (2)	21%, 62%

*Sheep data from Dove and McMullen (2009) and H. Dove and W.M. Kelman (unpublished data); cattle data courtesy of R. van Es (University of Western Sydney) and J. Minehan (Landmark, Goulburn).

The response of liveweight gain to either supplement alone has thus been consistently of the order of 15-25%, with an at least partially additive response when both supplements are offered together. The supplement itself costs from one cent (sheep) to ten cents (cattle) per day and response to supplementation has been valued at 15-20 times this. The response is thus highly economic and in SE Australia, producer uptake of Mg/Na supplementation has been rapid.

Investigation has shown that the responses relate not just to the Mg content of winter wheat forage, but to its very low Na content and very high K content. The concentrations of the latter two minerals come about because of the presence in bread wheats of the K/Na1 gene (Gorham *et al.* 1987), which operates to exclude Na from leaves whilst maintaining ionic equilibrium by accumulating K. It is significant in relation to grazing animals that the effect of this gene is most marked in newer leaves. Though the Na exclusion allows bread wheats to tolerate a degree of soil salinity, it also results in forage with an extremely high K:Na ratio which, in the rumen, markedly decreases the absorption of Mg. The response to Na supplementation thus represents not only a response to Na as such, but also a response to improved Mg absorption as a result of the Na supplement reducing the dietary K:Na ratio (see Dove and McMullen 2009). Studies near Canberra have shown that Mg concentrations in wheat forage can also be increased by fertilising the crop with $MgSO_4$ or dusting it with MgO (H. Dove and W.M Kelman, unpublished data). However, animal responses to this route of Mg supplementation have been erratic and costly, relative to direct supplementation of animals. Moreover, the approach does nothing to address the low Na intakes and high dietary K:Na ratios.

Further studies with sheep grazing oats, barley or canola have shown that Mg/Na supplements are not required when grazing these crops because of their much higher forage Mg and Na contents (Dove 2007; Dove *et al.* 2011). Responses to supplementation with triticale have been variable, reflecting the variability in its Na content, but supplementing livestock grazing triticale is probably cheap insurance. GRDC investment in this aspect of grazing dual purpose crops has yielded very positive results which have proved highly profitable and have been rapidly adopted by producers in SE Australia.

3.5.9. Grazing of other cereals and canola

Many of the issues raised above in relation to grazing of dual purpose wheats can be applied equally to the grazing of other cereals. There is a large literature on the grazing of forage oats, which has been practised for decades, but relative to this and the literature on the grazing of wheat, we still lack information on the grazing of barley and triticale in Australian grazing systems. As discussed above, a significant feature of these other cereals is that livestock grazing them will not require supplementation with Mg/Na.

Forage brassicas, sown in spring and grazed over the summer period in Australia, have long been a component of livestock-grazing systems. These can be sown in the spring before a later early autumn sowing of winter wheat and result in substantial output of lamb liveweight from a grazing system (e.g. Kelman and Dove 2007). However, due to the use of soil water by the forage brassica over spring/summer, this system can 'starve' the subsequent winter wheat crop for water and result in reduced grain yields (e.g. Kelman and Dove 2007). An alternative approach, by analogy with winter-wheat grazing, is the possibility of using early sown canola as a winter forage resource. GRDC-funded studies in southern Australia have demonstrated that canola crops, particularly long-season canolas, can be grazed by sheep during winter with no marked effect on seed yield or oil content (e.g. Kirkegaard *et al.* 2008). For example, Kirkegaard *et al.* (2008) recorded seed yields of 4.8, 4.1 and 4.1 t/ha in ungrazed cultivars Hyola 60, Maxol and Capitol, respectively. Equivalent seed yields in grazed crops were 4.6, 4.3 and 4.0 t/ha, respectively. The mean *in vitro* digestibility (0.80) and crude protein content (20.4% DM) of the cultivars indicated their forage was of high quality. Measurements of grazing behaviour, diet selection and intake indicated that contrary to a frequent farmer perception, sheep had no preference for forage brassica (cv. Hunter) over canola forage, nor did they prefer to consume 'other species' cf. canola. Sheep spent 86% of their grazing time actively grazing canola and 85% of the forage consumed consisted of canola. The *in vivo* digestibility of this consumed diet was 0.86±0.01 and at the stocking rate used (33/ha), the sheep grew at 210 g/d (Kirkegaard *et al.* 2008).

The results of this work have established that canola can be grazed as a dual purpose crop in much the same way as winter wheat, and thereby provide such wheats in higher-rainfall areas with a 'canola break-crop effect' analogous to the use of spring canola as a break crop in rotations in the cereal-livestock zone.

The work has also generated a useful set of 'best-bet' management rules for the grazing of canola (Kirkegaard *et al.* 2011) which, from a livestock perspective, include:

1. Sow early (late March to mid-April) with a long-season variety.

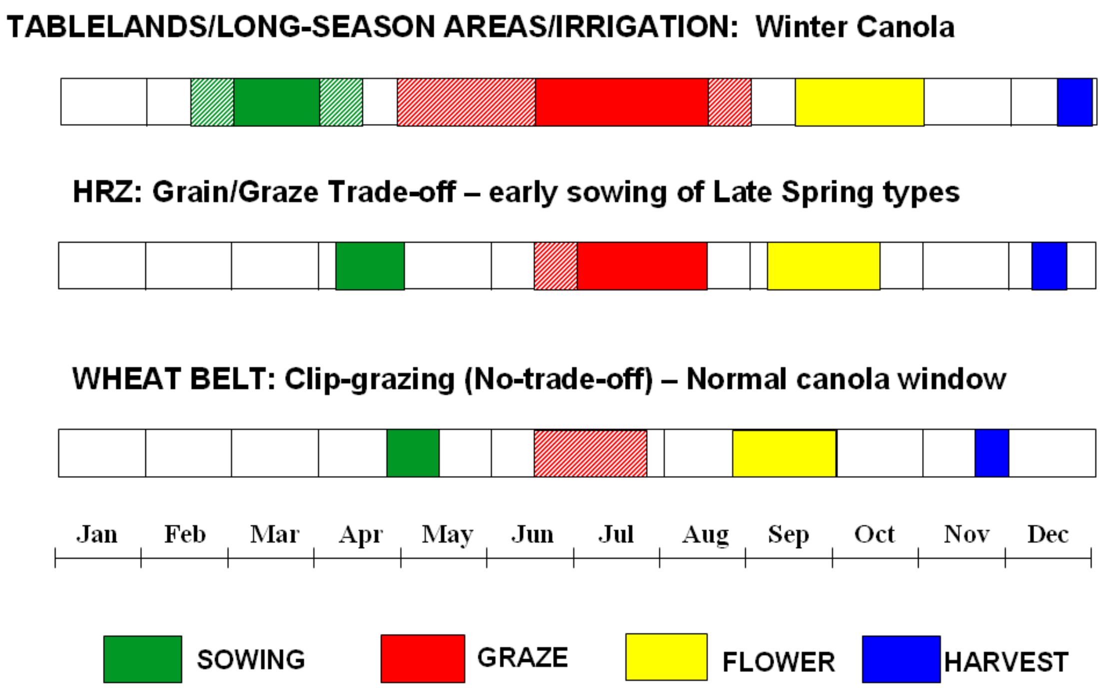
2. Grazing can increase both the incidence and severity of blackleg, a major disease of canola, so it is important to sow varieties with high early vigour and good blackleg resistance. When considering insect and weed management, it is important to consider the required pre-grazing withholding periods for any chemicals used.

3. Use sowing rates which will achieve a good plant density (at least 50 plants/m^2) and ensure adequate fertility for good early growth. Nitrogen topdressing and some weed control can be delayed until after grazing. Do NOT apply N if grazing is about to commence. This can lead to nitrate accumulation in canola forage and result in nitrite toxicity in livestock.

4. Grazing can commence when plants are well anchored, biomass is adequate (~1.5 t/ha), and withholding periods have been met. This usually means grazing from mid-June or 6-8 leaf stage for April sowings (Figure 14).

5. As with dual purpose wheat, timing of stock removal is a key decision and is more important that the timing of the start of grazing or the stocking rate used. To avoid yield penalties, remove stock before developing flower buds have elongated more than 10cm above ground level.

Figure 14: Chart of annual cycle of sowing, grazing opportunity, flowering and harvest of canola in the NSW Tablelands, High Rainfall Zone (HRZ) and Wheat belt (Kirkegaard, pers.com.)



Specific indirect benefits of dual purpose canola (cf. grain-only canola) include the reduction in the height and bulk of vigorous high-yield potential crops, facilitating ease of windrowing and harvest at considerable economic saving and reduced lodging risk in high-yielding years. In addition, dual purpose canola provided producers with a high-value alternative to dual purpose wheat when WSMV prevented early (March) sowing after 2005. The use of dual purpose canola in the year before dual purpose wheat will also greatly reduce the chance of WSMV infection.

3.6. Capturing livestock and crop benefits in a whole-farm system. If grain/seed yield penalties arising from grazing can be avoided or minimised, then increased gross margins/ha for dual purpose *v.* grain-only paddocks of either cereals or canola can be obtained. However, there might be even greater benefits at the wider system or farm scale resulting from complementarities between cereal and canola, and from the spelling of pasture which occurs during crop grazing. These include:

3.6.1. Pasture spelling

If animals are removed from pasture during winter in order to graze either cereal, canola or both crops in sequence, this provides a period of pasture spelling which, if substantial enough, could provide a 'wedge' of late-winter feed for livestock. In a GRDC-funded systems experiment in Canberra in 2010, the value of spelling a phalaris-subclover pasture was quantified during winter grazing of either a wheat crop alone (Mackellar), a canola crop alone (Maxol), or a sequence of the canola and wheat, all grazed by Merino hoggets (Dove *et al.* 2011). The grazing days obtained from crop grazing and also from the extra pasture production in the pastures spelled during the crop grazing were calculated and expressed in terms of the extra grazing days achieved in each treatment, compared with continuously grazed pasture (Table 14). The grazing of a single crop resulted in about 800-1200 extra SGD/ha (cf. continuously grazed pasture), whilst grazing both crops in sequence allowed almost 2100 extra grazing days. Removal of stock from pasture for crop grazing resulted in extra pasture growth and many more pasture-grazing days post-crop grazing. In fact, of the total extra sheep grazing days/ha of 1500-1700 (one crop) or 3456 (both crops), no less than 30-47% arose from the spelling effect on pasture of the crop grazing. This indicates a substantial extra benefit to be gained from dual purpose crop grazing. To date, this benefit has been quantified in only one year for one pasture-based system.

Table 14. Extra sheep grazing days (SGD/ha) obtained by grazing wheat, canola or canola+wheat in sequence, and the extra sheep grazing days obtained by the subsequent grazing of winter-spelled pasture (all relative to continuously grazed pasture)

Treatment	Crop extra SGD/ha	Pasture extra SGD/ha	Total extra SGD/ha	% of total from extra pasture
Wheat grazing	1188	521	1709	30.5
Canola grazing	822	739	1561	47.3
Canola+wheat	2076	1380	3456	40.0

3.6.2. Weed and disease control

The possible impact of grazing on disease incidence has already been mentioned. In addition, producers are increasingly viewing crop grazing as a key component in weed control, both in the crop phase and in relation to future pasture establishment. As an example of such effects in the crop phase, the increased grain yield recorded in grazed Mackellar wheat in 2010 (see Figure 12) was due to the much higher weed incidence in the ungrazed crop.

3.6.3. Livestock management consequences and benefits

To capture the benefits of the extra sheep grazing days afforded by grazing systems based on pastures plus crops, producers either have to have extra animals or obtain the money required to buy them. From the results in Table 13, it can be calculated that, relative to the carrying capacity of continuously grazed pasture over the grazing period May-December (12.8 sheep/ha), the implied carrying capacities of the treatments involving crop grazing were greatly increased, as follows: (pasture+wheat) 20.7 sheep/ha; (pasture+canola) 20.3/ha; (pasture+canola+wheat) 28.7 sheep/ha. These increases, whilst real, in part reflect the proportion of crop to pasture in the experimental treatments. On a whole-farm basis, increases in carrying capacity will be smaller because of the likely lower proportion of crop on a whole-farm basis. Nevertheless, the possible costs of obtaining extra animals need to be factored into any whole-farm comparison of grazing options. There is a need for more such research and within it, a role for modelling work to extend research results to other systems.

A wholly unquantified effect of the grazing of dual purpose crops is that it may permit a re-evaluation of the timing of major livestock operations such as calving or lambing times, for example in the Mallee to finish lambs “out of season” for higher prices. Another example is an accepted potential problem in sheep-grazing systems with autumn lambing, since lactating ewes, or their early-weaned lambs, enter the winter period with high nutrient demands but scarce pasture supply. One experimentally unexplored consequence of grazing systems involving pasture plus crop is that crop grazing would overcome this feed shortage and thus potentially would allow autumn lambing, with a resultant longer period to finish weaned stock for end-of-season markets. Nevertheless, farmers are now introducing autumn lambing based on confidence in establishing their feed budgets with grazing dual use crops. One option initially adopted has been to move half of the lambing to autumn but retaining the other half in spring. (Rowett 2011). Similarly, if crop grazing is a major component of the system then there may also be consequences for helminth control, to the extent that the crop itself and possibly the spelled pasture could substantially be free of helminth larvae.

In cropping systems based on dual purpose, long-season wheats, the higher yield potential of such varieties can result in large quantities of crop stubbles, often >5 t DM/ha. This, coupled with the brief period between the later harvest time of such varieties and early sowing in the subsequent year, can generate greater problems in relation to stubble management. Compared with the early work on using livestock grazing as a component of stubble management (e.g. Coombe and Mulholland 1983), there has been much less work on livestock/stubble management interactions in dual purpose cropping systems. Moreover, we do not yet know whether livestock grazing wheat stubble require the same Mg/Na supplements to which animals respond when grazing vegetative wheat. The answer to this will depend on the respective K:Na ratios in the dry leaf and stem fractions of the stubble, and the leaf:stem proportions in the stubble. This aspect remains unresearched but supplementation might contribute to improved stubble utilisation by livestock.

3.7. The potential impacts of dual purpose crops on plant diseases

3.7.1 Wheat rusts

The cereal rust pathogens in Table 15(R Park and C Wellings, personal communication 2011) are biotrophic and can only survive and reproduce on living host tissue. Rust pathogen populations crash during the hot non-cropping summer period in Australia, surviving on grasses and volunteer (self-sown) cereal plants (collectively referred to as the "Green Bridge"). Cropping cereals outside the traditional winter-spring period increases opportunities for rust inoculums carry-over from one season to the next, significantly increasing epidemic potential in the following cropping cycle (Park, 1997).

Table 15. Cereal rust pathogens and diseases present in Australia, 2011

Crop	Rust pathogen	Disease
Wheat/ Triticale	*Puccinia graminis* f. sp. t*ritici*	Stem rust
	P. striiformis f. sp. t*ritici*	Stripe rust
	P. triticina	Leaf rust
Barley	*P. graminis*[1]	Stem rust
	P. hordei	Leaf rust
	P. striiformis "BGYR"[2]	Stripe rust
Oats	*P. graminis* f. sp. *avenae*	Stem rust
	P. coronata f. sp. *avenae*	Crown rust
Cereal rye	*P. graminis* f. sp. *secalis*	Stem rust
	P. secalina	Leaf rust

[1] Stem rust of barley can be caused by *P. graminis* f. sp. *Tritici* (*Pgt*), *P. graminis* f. sp. *Secalis* (*Pgs*) or a third form known as the "scabrum" rust, which originated via somatic hybridisation between *Pgt* and *Pgs*.
[2] "BGYR", the Barley Grass Stripe Rust pathogen, is weakly pathogenic on barley, causing stripe rusting of only Skiff, Tantangara and Maritime.

Early sowing of cereals, including dual purpose cereals, shortens the traditional non-cropping phase and if the cultivars sown are vulnerable to rust infection, provides a host on which these pathogens can undergo early build-up. In order to maintain the value of dual purpose cereal varieties to the industry, scientists from the Australian Cereal Rust Control Program (ACRCP) believe that greater effort is required to provide genetic and, where appropriate, chemical protection that places this sector on a sustainable foundation. In addition to other traits that may be sought in dual purpose cereals, there is a need to fund adequately breeding and pre-breeding activities that incorporate genetic protection from rust in early sown cultivars, thereby restricting the build-up of inoculums that could affect main-season plantings. The concerns with the potential impact of dual purpose cereals in rust epidemiology relate principally to wheat and triticale. While early sown oats can also expedite early inoculum build-up of particularly crown rust, vast stands of wild oats occur in all oat growing regions, acting as a reservoir of inoculums and contributing significantly to rust epidemics in oats.

Experience with the epidemiology of stripe rust in Australia has shown that dual purpose wheat and triticale represent a real threat to main season plantings of these crops through the development of early rust disease pressure (Wellings CR, unpublished) The ACRCP has collected evidence that links time of first disease recorded and severity of epidemic development: for stripe rust over the past 30 years, the correlation now exceeds 60% (Figure 15). In the past 10 years, first reports of stripe rust have come from early sown wheat cultivars such as Marombi, Mackellar, Whistler and Wedgetail, and more recently from triticale cultivars Jackie and Tobruk. The latter cases resulted from adaptation by the stripe rust pathogen to triticale, via the acquisition of virulence for resistance genes "*YrJ*" and "*YrT*", both present in the rye genome (Wellings and Kandel, 2010; unpublished).

Scientists with ACRCP believe that efforts to improve crop protection against cereal rusts in early sown wheat and triticale will have enormous benefits in protecting main season grain crops by reducing inoculums pressure, extending the durability of deployed resistance genes and thereby preserving the investments in developing resistant varieties for the Australian grains industry. Protection against cereal rusts will also be needed to underpin the development of perennial types of wheat for Australia, a topic that is under consideration (Bell et al. 2010).

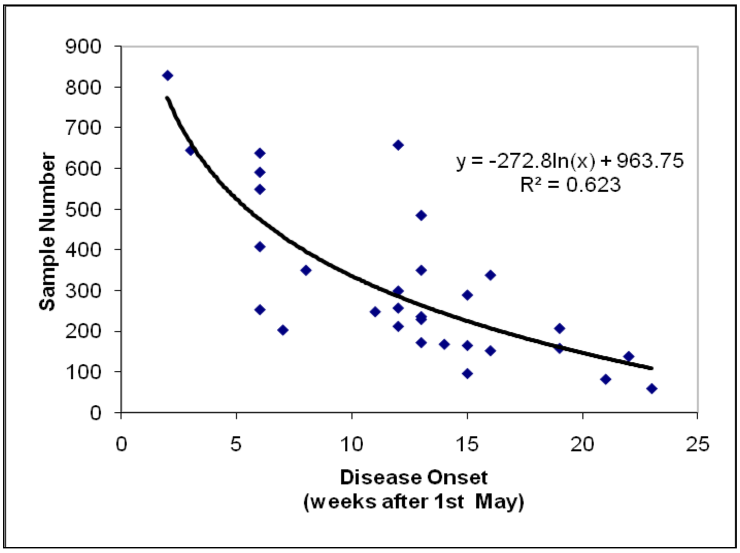


Figure 15 The relationship between time of disease onset in commercial fields (weeks after 1st May) and final sample numbers received in the annual pathotype survey for stripe rust (*Puccinia striiformis*), 1980-2010 (Wellings CR, unpublished).

3.7.2 Wheat streak mosaic virus

Experience in SE Australia over the last decade has shown that early-sown wheat can be exposed to a greater risk of wheat-streak mosaic virus (WSMV), due to the presence over summer of green material capable of being an alternative host for the wheat curl mite (the WSMV vector). In SE NSW in 2005, extensive outbreaks of WSMV in grazed crops resulted in a widely-held view amongst producers that grazing itself was the prime cause of increased WSMV infection, and dual purpose wheat sowings were reduced as a consequence. However, early evidence from the USA coupled with more recent gene-technology based research in Australia (Muhammad *et al.* 2010) has shown that increased WSMV incidence is not due to the grazing process itself and is more likely related to crop/weed hygiene over the preceding summer. Strict attention to this, or sowing the wheat after canola, will reduce the risk of WSMV.

3.7.3 Barley yellow dwarf virus

Barley yellow dwarf virus (BYDV) is transmitted by aphids. Early sown cereal crops are more at risk because there is typically a peak in flying aphids in the autumn. In general wheat and triticale are more tolerant to BYDV than barley and oats. There is a reasonable level of resistance available in wheat, and tolerance genes that can be incorporated into barley varieties. Multigenic, moderate levels of tolerance are also possible in oats. In order to prevent disease losses, either tolerant or resistant varieties must be sown or landholders must control aphids (Matthews and McCaffery 2011). Imidacloprid is an insecticide that is registered for use on cereal crops as a seed dressing for the management of aphids and their spread of BYDV.

4. ECONOMIC ANALYSES

There appear to be relatively few economic analyses, as distinct from physical analyses comparing the use of dual purpose crops in livestock/cropping environments compared with cropping only regimes.

Economic analyses can be too simplistic (kilos on, kilos off) without taking into account the full effects of dual purpose crops on the farming system. For example early-sown dual purpose crops may contain more weed which may pose a threat to the crop later in the season or to the paddock in the following year if stock preferentially graze the sown dual purpose cereal crop. Conversely, where weeds appear in a canola crop, there is evidence that preferential grazing helps control the weeds as well as taking advantage of the early bulk of canola. Discussion often focuses on the probability of getting an additional quantity of feed without taking into account the consequent risks to subsequent crop yield if grazing is not withdrawn in sufficient time. But there may be a subsequent additional increment of later pasture feed resulting from deferred grazing of pastures, allowing them to “get away”. Questions farmers face include whether the additional feed will fill a gap, partially fill it or postpone the gap; can the gap be obviated by some other strategy such as changing the time of lambing or containment feeding? Are growers able to manage with confidence the tradeoffs that may vary between localities, farming systems, commodity prices and season?

Recollection of an economic analysis by Dirk Godyn in the early 1980s was that it showed modest benefits to the livestock component on farms from the use of dual purpose oats, possibly exceeding any penalties due to the choice of lower-yielding crop varieties or the occasional yield depression from grazing. However, the grain yield potential of dual purpose oat varieties subsequently fell well behind the potential of grain-only cultivars.

Using data from field trials carried out in 2004 by Chris Powell (NSW Agriculture), an examination was undertaken by Brennan (2011) of returns from various dual purpose crops, adopting then prevailing f.o.b. market prices per tonne (Wheat:- Feed $154, ASW $187, APW $197, AH $205, APH $218, Barley:- Feed $138, Oats:- Feed $113, Milling $143, Triticale:- Feed $150), a $40/tonne handling charge, variable on-farm costs (from NSW Agriculture budgets, plus top-dressing costs) and a price of $1.80/kg of liveweight gain, The results are shown in Table 16. The best returns came from wheat cultivars that had good grazing value, high grain yield and high quality grain, as one would expect. The lowest returns were provided by oats due to poorer grain yield and value.

Table 16. Dual purpose Crops: Economic Comparisons and Ranking (Brennan 2011)

Crop	Grade	Variety	Grazing value $/ha	Grain value $/ha	Variable costs $/ha	Net returns $/ha
Wheat	AH	Sunbrook	562	533	297	798
Wheat	AH	Wylah	561	533	297	796
Wheat	APH	EGA Wedgetail	573	514	297	790
Wheat	ASW	Marombi	504	548	297	754
Wheat	ASW	Whistler	559	469	297	730
Wheat	ASW	Rosella	565	456	297	723
Wheat	APW	Pardalote	566	450	297	719
Wheat	ASW	Lorikeet	559	425	297	686

Crop	Grade	Variety	Grazing value $/ha	Grain value $/ha	Variable costs $/ha	Net returns $/ha
Wheat	Feed	Currawong	575	398	297	676
Wheat	ASW	Petrel	559	404	297	665
Wheat	Feed	Mackellar	489	430	297	622
Triticale	Feed	Eleanor	587	308	276	618
Wheat	Feed	Brennan	527	380	297	610
Wheat	Feed	Dennis	510	396	297	609
Wheat	Feed	Gordon	513	390	297	606
Wheat	Feed	Rudd	492	406	297	601
Triticale	Feed	Hillary	568	308	276	599
Triticale	Feed	Maiden	553	320	276	597
Triticale	Feed	Jackie	534	333	276	591
Wheat	Feed	Tennant	462	404	297	568
Oats	Feed	Eurabbie	620	216	302	534
Wheat	Feed	Warbler	489	340	297	532
Triticale	Feed	Madonna	480	305	276	509
Barley	Feed	Yerong	515	263	318	460
Oats	Feed	Bimbil	585	170	302	453
Oats	Feed	Yiddah	587	167	302	452
Oats	Feed	Carbeen	564	153	302	415

A thirty-year horizon analysis by Bathgate (2008) as part of the Grain and Graze Program showed using an example of a 1000 ha mixed farm with four soil types in the Coolamon region of NSW (rainfall 450 mm/yr) growing wheat, barley, canola and lupins, pasture and lucerne and running sheep for wool, that grazing 500 ha of wheat compared to no grazing would increase farm profit by $8000 per annum. The model assumed a grain yield reduction of 10% due to grazing, with commodity prices of $150/tonne, canola at $314/tonne and wool at 750 cents/kg clean. The model showed that if a larger area of crop were grown, profitability would decline unless the crop is grazed and increased stocking rate would be required (Figure 16)

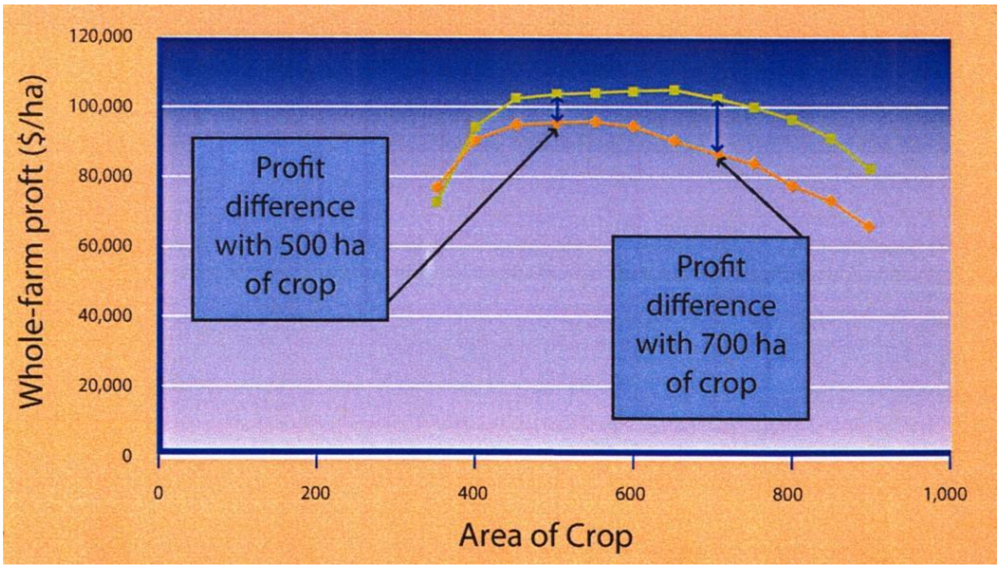


Figure 16. Relationship between crop area and profitability, 1000 ha farm, Coolamon NSW (Bathgate 2008)

However, some conclusions can be drawn. In general, crop grazing results in about 1000-2000 DSE grazing days/ha and provides $150-450/ha higher paddock gross margin than a grain-only crop. Even if these benefits are not fully realised, there should also be other gains through reducing the stocking rate on the pasture area. These various aspects are discussed more fully by Harrison *et al.* (2011).

Where winter and spring genotypes of canola were evaluated for a dual purpose role in the Canberra environment (Kirkegaard et al. 2008), the mean gross margin for dual purpose canola over four experiments was $240 to $500 higher than for grain-only canola depending on the value assumed for the forage. The study indicates there is considerable scope to capture value from grazing early-sown canola crops during winter without significant, uneconomic trade-offs with seed yield. Further investigations in other medium to high rainfall environments in southern Australia are warranted.

Economic data were presented at the Grain and Graze 2 “Grazing Crops Forum” held in Perth on September 26 2011 with thirty participants sharing their experiences and ideas regarding how grazing crops are used in WA (England 2011). The forum provided equivocal information about Western Australian experience with dual purpose crops. The majority of data showed reduced yields from grazed crops, and the financial evaluations of the extent to which grazing income offset reduced yields was variable. Trials at Binnu showed a profit for grazing of one canola variety compared to a loss on the ungrazed crop. Grazing, though still loss-making, reduced the loss on four other canola varieties compared with their ungrazed equivalents. A gross margin summary from three sites showed an additional benefit of $11/ha at Dalyup, but lower gross margins of minus $13/ha and minus $63/ha from Mount Howick and Cascades respectively from grazing crops. Further economics is being pursued in Western Australian dual purpose crops research.

5. BREEDING, EVALUATION AND COMMERCIALISATION OF DUAL PURPOSE CROPS

5.1 Overview

As indicated earlier in this document, dual purpose crops/varieties are taken to mean crops that are sown deliberately for both grazing during their vegetative stage (May-July in Australia) and for grain harvest (November-December). For these purposes, such varieties are ideally sown in autumn (March-May in Australia), several weeks before the mainstream grain varieties are sown in late autumn or early winter, so that:

- A pool of green biomass is available for livestock grazing during the late autumn and winter feed troughs; and
- Crop-sowing activities are conveniently timed in relation to rainfall and the availability of machinery/labour for sowing.

A 'winter crop variety sowing guide' is produced each year by State Departments of Agriculture and Food, Primary Industries etc.. One of the most comprehensive of these guides is the one produced by NSW Department of Primary Industries, a guide that is available online or in print (Matthews and McCaffery 2011). This guide provides information on all winter crop types and varieties that are recommended in the grain-growing areas of NSW, as well as information on the recommended sowing time for each, varietal characteristics, their reaction to disease, and their yield performance in experiments conducted during several previous years. In Annex 1, lists are given of the crop varieties recommended in 2011 together with some basic information on their traits and suitability for sowing as dual purpose crops. These lists were based on the New South Wales winter crop variety sowing guide but some modifications were made after discussing the dual purpose status of the varieties with crop breeders/physiologists (Martin, *pers. comm*.). Thus, a variety that has:

- A habit of 'spring' and a classification of 'no' is a genotype in which floral initiation seems to be a function of growing day degrees (warmth), and so it is unsuitable for early sowing;
- A habit of 'spring' and a classification of 'dual purpose' is a genotype in which floral initiation seems to be controlled by a photoperiodic stimulus rather than by a vernalisation (cold) stimulus, or both stimuli. Such a variety can be sown earlier than mainstream varieties (but refer to the recommended sowing time);
- A habit of 'winter' and a classification of 'dual purpose' is a genotype in which floral initiation seems to be controlled a vernalisation (cold) stimulus, or a combination of both stimuli (photoperiod and cold). Such varieties can be safely sown early without premature floral initiation.

The papers published by Eagles et al. (2009, 2010) explain the state of knowledge concerning the operation of four important genes (and their alleles) that are important for the adaptation of flowering and maturity in wheat varieties to different environments in southern Australia. The genes concerned are the photoperiod gene *Ppd-D1* and the vernalisation genes *Vrn-A1*, *Vrn-B1* and *Vrn D1*. Furthermore, diagnostic molecular markers are available for detecting important alleles of these genes, facilitating the selection of a particular set of genotypes for use in various warm or cold winter environments and for particular purposes (e.g., early sowing, late sowing). These workers identified four main combinations of alleles of these major genes in modern Australian wheat cultivars. For example, a combination of the *Ppd-D1a* allele, the spring *Vrn-A1a* allele and the winter alleles at *Vrn-B1* and *Vrn-D1* was associated with varieties similar to WW15 (Anza), which was a progenitor of many dual purpose cultivars with the winter habit (Eagles et al. 2009). Furthermore, since the alleles of these genes interact (epistasis), the selection of specific habits can be achieved by selecting for specific combinations of alleles, using marker-assisted selection (MAS) (Eagles et al. 2010). In spite of this knowledge, these genes still only explain about 45% of the genetic variance for days to heading (Eagles et al. 2010). It is therefore still necessary to grow these genotypes in the environments where they are targeted.

Hence, the selection of wheats with maturity suitable for early sowing and hence the dual purpose role can be done without difficulty. This selection strategy can be achieved both in the laboratory (MAS) and/or by sowing crossbreds early in the season (e.g., late February to early March) and discarding those genotypes that flower early or have other unfavourable traits (e.g., slow growth). The diagnostic markers for the Vrn and Ppd genes are available for use by breeding programs. Presumably through the phenomenon of synteny (species of relatively recent divergence showing similar blocks of genes in the same relative positions in the genome), similar gene combinations exist in other crop types (barley, triticale, oats, canola), and hence the potential exists to select dual purpose varieties.

A range of traits required in main-season varieties are also required in dual purpose wheat varieties. These traits include stem, leaf and stripe rust resistance and milling quality (with all the characters associated with this). Tolerance and/or resistance to BYDV and WSMV confer large advantages on dual purpose wheat varieties. Markers for BYDV resistance in bread wheat are available for use in wheat breeding programs. Markers for resistance to WSMV are not available at the moment but are under development by CSIRO.

It is not possible to define and ideotype dual purpose for all regions of Australia. The variation in growing season rainfall, season length, soil type, variation in photoperiod, rate of vernalisation etc. mean that the phenotype for dual purpose should be defined by agro-ecological zone.

5.2. The recent history and future capacity for breeding dual purpose varieties

5.2.1 *General Observations*

For this review, the number of people interviewed was not necessarily comprehensive but the range comprised a representative cross-section of breeders, managers, seed marketers and agronomists employed by breeding and seed companies. A list of those contacted has been made available to GRDC but not for the public.

Potentially, there is an extensive list of potential partners for dual purpose crop development within the private sector. These include but are not limited to the following: AGT, LongReach, Intergrain, HRZ; smaller seed companies (Heritage, Grain Search, SeedNet, Valley Seeds, Seed Distributors, Waratah seeds); Universities such as the University of Sydney and University of Adelaide who currently run breeding programs; other universities, State departments and CRCs who are conducting related agronomic, genetic or physiological research (e.g. the Grain and Graze initiative); and some private agronomists who are currently running their own experiments. However, for various reasons that are outlined below, the ‘interest’ in dual purpose crops is often driven by funding rather than by genuine industry needs.

The breeding of DPC varieties, other than the DPC milling wheat varieties currently being bred by the major private wheat breeding companies, appears to be not economically viable in its own right and needs the financial support of public monies.

There is considerable concern within the breeding industry about the "leakage" of dual purpose varieties over fencelines to neighbours and the inability of the companies to collect appropriate royalty streams to justify the investment in breeding of crops with grazing attributes. Breeding dual purpose crops will only continue if it is a viable proposition. If this leakage continues then the current investment in breeding dual purpose varieties may well diminish or cease entirely.

5.2.2 Wheat.

During the 1990s and 2000s, GRDC funded, at least in part, several programs which were breeding dual purpose wheat. These programs included the NSW DPI project at Wagga funded as part of Enterprise Grains Australia, the CSIRO dual purpose feed project (CSP101) and the HRZ Pty. Ltd. Breeding project. In addition, some resources were devoted in the University of Sydney breeding program based at Narrabri to dual purpose breeding and in the Victorian DPI breeding program at Horsham to breeding long season wheats. These programs produced a steady stream of dual purpose varieties but, with the susceptibility many varieties to new races of rust and a string of dry years that prevented early sowing, grower interest waned during the 2000s. Furthermore, the wheat breeding landscape has changed quite dramatically, with wheat breeding being transferred from public institutions to private companies such as AGT, LongReach and Intergrain and the subsequent development of a National Research and Development Strategy for the Grains Industry (PISC 2011). There was very little interest amongst private breeding companies in breeding dual purpose wheat in the period from 2007 until 2010. The NSW DPI breeding project was closed after the 2006 growing season.

Exceptions to this pattern were the CSIRO dual purpose feed wheat program and the HRZ dual purpose program. The dual purpose feed wheat project is funded by GRDC to breed dual purpose wheat varieties for the high rainfall zone. HRZ is a partnership between CSIRO, Plant and Food New Zealand, Landmark, Dow Agrosciences and GRDC and it aims to produce milling grade wheat varieties for the high rainfall program. CSIRO has advised that these projects are run separately and independently and there is no exchange of breeding material between projects without intellectual property agreements being put in place. At Canberra, a CSIRO wheat breeder spends 50% of her time on feed wheat and 50% on milling wheat. CSIRO is in the process of recruiting a breeder to run the HRZ project. There will be two breeders in New Zealand, one allocated to each of the projects, who undertake the evaluation of parental material, crossing and selection. Both the dual purpose and the HRZ projects are importing material from around the world, making crosses and selecting within the high rainfall areas of Australia.

By the beginning of 2010, there was evidence of renewed interest from commercial breeding companies in breeding dual purpose milling grade wheats for what has traditionally been the south-eastern fringe of the Australian wheat belt, from Coolah to Mt Gambier. The winter germplasm that had been stored in a cool room at Temora because there was initially no interest in commercialising it became a source of non-segregating breeding lines, made available on a nonexclusive basis to a range of breeding and seed companies that requested these materials. Furthermore, seed of segregating earlier generation breeding lines was provided to some of the breeding companies. Overall, the materials despatched included 518 stage 3 lines, 263 stage 1 lines, 354 F5-derived fixed lines and 1024 F2-derived F4 lines. The breeding and seed companies are using this germplasm in a range of ways, including the evaluation of fixed breeding lines for the purpose of release, reselection of segregating populations for the purpose of release and the use of lines as parents in crossing programs. Equity in this breeding material is the subject of contracts between NSW DPI and the breeding and seed companies. Other materials have been imported through the Australian Winter Cereals Collection. The breeding companies appear to be devoting sufficient resources to their dual purpose wheat programs to provide ongoing access to improved varieties in the medium to long-term.

Australian Grain Technologies Pty Ltd has advised that 30% of a breeding program based in Horsham is directed towards long season varieties, and of that, more than half of the long season variety activity is towards EGA Wedgetail type varieties, meaning that 15% of total breeding effort is focused on breeding an improved EGA Wedgetail type variety. Biomass cutting work is also undertaken at Roseworthy. AGT has estimated that it is 2 -3 years away from being able to release a number of EGA Wedgetail type replacement varieties. Depending on 2011 trial results one variety with EGA Wedgetail type 'winterness', may be available for launch in 2012. This variety is not as good as EGA Wedgetail for acid soils and will only be released if it gains a minimum APW milling classification (Eastwood 2011).

HRZ Wheats Pty Ltd has released Forrest, an APW quality wheat variety which is the first variety resistant / tolerant to WSMV ($3.85/tonne EPR). It is a facultative type and has a shorter growing season than EGA Wedgetail but will be able to be planted late April/ May and will be suitable for grazing. Landmark R&D (a shareholder in HRZ Wheats) has been conducting the grazing system trials (Neilson 2011).

LongReach Plant Breeders Pty Ltd has some Wedgetail, Naparoo, Forrest type material still being evaluated. The company has encouraged trial collaborator companies to offer grazing assessment trials as part of their service offer. NSW DPI was still completing dual purpose trials in 2011 and requested LongReach lines for entry (Edmondson 2011).

5.2.3 Barley

Barley breeding in Australia has undergone considerable change and rationalisation over the past several years. Barley Breeding Australia no longer exists. It has essentially been replaced by breeding programs conducted by commercial companies. Some importation and evaluation of varieties is conducted by a number of seed companies. Breeding lines from the previous breeding programs, formerly undertaken by State Departments and/or Universities, were subsumed into the arrangements that now exist between breeders, their organisations and commercial companies for the development and release of new varieties. Currently, none of the barley breeding companies have the dual purpose type as a breeding objective. The Queensland barley program at the Hermitage Station has an orientation which seeks to maximise grain yield in good seasons but has capacity to develop adequate dry matter yield for grazing or hay in poor seasons. The winter season is considered too short to encompass true dual yield objectives (Franckowiac 2011). The NSW DPI breeding program, the only program that had dual purpose winter barley as one of its breeding objectives, no longer exists. In consultations with the current breeding companies, it was clear that they consider that such an investment is not viable commercially. A view was expressed that many or most existing grain varieties appear suited to opportunistic grazing, a potentially worthwhile characteristic. Most varieties' ability to recover after an early hard grazing is such that an additional effort into establishing a separate dual purpose breeding program for traits for grazing and subsequent recovery may not be necessary (Eglinton 2011). Several seed companies are involved in the limited importation and evaluation of germplasm that may be suitable as forage only types.

5.2.4 Oats

There is currently one oat breeding program in Australia, the *National Oat Breeding Program for Milling and Feed End Uses (NOBP)*(GRDC DAS00091) with an adjunct program *Breeding stem rust resistant oat using wild Avena species* (DAS00102). They are funded by SARDI, GRDC and SAGIT. NSW Agriculture had initiated an oat improvement program in 1904. The original breeder was Dr J Pridham. He recognised the major role of oats in NSW as a dual purpose crop which could be sown early in autumn, grazed through the winter and allowed to recover a grain crop during the spring. Largely through his recognition of the important role oats played in the grazing industries and his efforts in selecting dual purpose varieties with suitable maturity the area sown to oats in NSW was substantially increased – around tenfold. Much of the breeding material in the Temora program continued to be based on the winter habited germplasm originally selected by Pridham. For several decades, NSW DPI with some funding from GRDC continued to maintain a dual purpose oat breeding program but it has now been closed (Roberts 2011). Thirty of the most advanced lines from the NSW DPI program were evaluated in trials in southern New South Wales over 2008-10. Pamela Zwer, the oat breeder for SARDI, has the responsibility for determining if any of these are worth commercialising. Seven lines are currently being evaluated for BYDV tolerance and these are being seed increased. Discussions about potential releases and the intellectual property of these oat breeding lines are planned between SARDI and NSW DPI in the coming months. The GRDC/SARDI program recently underwent an assessment of technical performance, operation and cost efficiencies and industry stakeholder satisfaction. It was determined that the program is effective in delivering against the agreed DAS00091 project milestones with the resources available to the program. The NOBP has successfully managed the amalgamation of the two former SA and WA breeding programs into a single operation via two nodes. The program is being asked to deliver against several breeding targets with different end uses, viz., grain, hay, and dual purpose grain/hay/forage and variable disease resistance issues which require the use of different gene pools or germplasm to be effective. This means that the program is essentially trying to operate three different breeding programs in three different target regions (equivalent to six breeding programs). This is further complicated in the case of both oat grain for milling and oat for hay by the expectation to meet potentially varying needs of domestic versus export markets. In reality this is too broad a program for a single chief scientist and associated team to handle and the review panel recommends focusing the NOBP on only grain for milling and oat for hay (Roberts, O'Brien and Rossnagel 2011).

An additional scientist is required if the program is to be effective in encompassing dual purpose oats. The current program does not access the grazing facilities that would be required (Zwer 2011). While mowing techniques to achieve defoliation as a simulation of grazing are comparatively inexpensive, they do not necessarily well represent all the soil and plant variables and selectivity of grazing. To achieve the ingredients of a revised selection strategy for the development of new dual purpose cultivars of oats, (and triticale and other cereals) it is recommended to breeders that they continue with or adopt the following principles:

(i) Place little initial emphasis on herbage production;
(ii) Use and select genotypes that possess a winter habit (ie, delayed reproductive development) and ignore questionable traits such as a prostrate morphology;
(iii) Apply heavy selection pressure for grain yield and quality as well as disease resistance, in early generations wherever possible
(iv) Any final checks on "grazability" should be reserved for advanced lines..

5.2.5 Triticale

Triticale breeding is currently conducted by the University of Sydney and AGT via GRDC-funded projects. The AGT program is by far the biggest of these breeding programs. There is also some evaluation activity being conducted by private breeding companies. Some seed companies are also importing germplasm from a range of sources. A component of both the AGT and the University of Sydney programs is devoted to breeding dual purpose triticale but their major emphasis is on grain only varieties. There appear to be insufficient resources available to conduct specific selection trials for grazing and grain recovery. The Pork CRC is a co-investor in triticale breeding and has recently released a new variety "Berkshire". Its R&D program has continued to focus on developing grain-yielding hybrids. Initial results from the 2010/11 season at trial sites of Gerogery and Cowra, NSW, indicated that heterosis in the hybrid program was disappointing in that parent heterosis averaged less than 5%, which is well below the 15+% required to make production of hybrids economic. The hybrid program will continue, but will rely on producing new hybrids from much more divergent triticale parents, which, hopefully, will achieve the 15+% yield improvement required. However, there appear to be insufficient resources available to conduct specific selection trials for grazing and grain recovery of triticale.

5.2.6 Canola

Rapeseed was first grown commercially in Australia in 1969 using Canadian varieties. Breeding began in Victoria, New South Wales and Western Australia in the early 1970s in response to the rapid increase in the disease "blackleg" (*Leptosphaeria maculans*), the arrival of which held back any significant development of the industry following an initial peak planting of 87 000 ha in 1971-2. Meanwhile in Canada, progressive development of germplasm and new varieties led to the Canadian Canola Council registering "canola" as a trademark for rapeseed (generally from either *Brassica rapa* [at the time *Brassica campestris*] or *Brassica napus*), now moving towards an updated definition denoting seed having a erucic acid content below 1% in the fatty acid profile of the seed storage lipid and a glucosinolates content below 18 micromoles per gram of seed at 8.5% moisture content. Complying rapeseed may access the "canola" appellation without royalty. Within Australia, the term canola is used to denote varieties that have an erucic acid level below 2% and total glucosinolates of less than 40 micromoles per gram of meal.

In 2000, there were at least four private sector canola breeding programs in Australia, together with three within the public sector (NSW Agriculture, DNRE Victoria and University of WA). Canola breeding has undergone considerable change. It is now conducted by private companies who own the varieties and germplasm. The Canadian scene is dominated by spring types with relatively small areas where winter types can survive due to winter freezing of the stems. Some areas in Eastern Canada can grow winter types.

Companies breeding and/or marketing canola or specialty *Brassica* varieties include Canola Breeders, Pacific Seeds, Pioneer, Nuseed, Cargill and Viterra. Much of the breeding effort is skewed towards GM traits (herbicide resistance, hybrid production). GM canola is still unable to be commercially grown in SA and Tasmania. All of the current commercial canola breeding companies are aware of the potential for dual purpose canola. Anecdotally, there are differences in early forage production between spring-habit varieties. For example, TT varieties are generally considered to be low in early productivity whilst hybrids and some conventional varieties have apparently demonstrated superior growth characteristics which make them suitable for a dual purpose role if they are managed appropriately. Currently the breeding companies do not have breeding programs specifically targeting dual purpose spring canola varieties but a number of companies are currently evaluating long season winter canola genotypes with a view to their release as dual purpose varieties. The winter habit could allow sowing at least as early as early March, before air/soil temperatures decline in late autumn and winter. Early sowing enables an accumulation of dry matter before the main feed gap (May-July), adding to the grazing potential of these varieties. Dual purpose winter canola varieties may profitably replace fodder rape in the farming system and provide a much more profitable crop. A joint project between GRDC and the four commercial breeding companies (Canola Breeders WA, Nuseed, Pacific Seeds and Pioneer) is testing early generation lines at three low rainfall sites in NSW, Vic and SA – many lines show promise for grazing and still recover to produce high yields and oil content (Thomas 2011)

The cultivar *Taurus* was released last year and is a direct import from Germany. Many varieties from Europe may fit well with phenologies spanning the required gap from winter through to spring types. Most produce significant biomass and recover well from grazing to produce excellent yield and oil. Blackleg tolerance is the first criterion. However without herbicide tolerance the early sowing of such varieties is problematic in many cases unless paddocks are (uncharacteristically) weed free.

5.2.7 Vetch

There are no truly selected dual purpose types of vetch available for use in the grain belt but vetch is included in this review because *Vicia* spp. appear suited to the soil types in Mallee districts. They are widely and increasingly grown with and without oats, barley or triticale as a grazed break crop and for fertility benefits in the face of rising fertiliser prices in rotations. There is also interest in Central-western NSW, but vetches have not significantly entered Western Australian farming systems where lupins occupy a similar niche. However, the prostrate habit of vetches means that the plants are damaged by trampling during the grazing period. Some growers are harvesting grain or hay after grazing, but unlike opportunities for cereal grains, there is a significant hay or grain yield reduction as a result of the grazing. The two species of vetch currently grown for hay, grain, grazing and green manure purposes are common vetch (*Vicia sativa)* and woolly pod vetch *(Vicia villosa*). The common vetch varieties Morava and Rasina were released by GRDC & SARDI as low cyanoglucoside replacements for the high public varieties Blanchefleur and Languedoc. High levels of cyanoglucosides are toxic to domestic animals and humans. Grain from Morava and Rasina can be fed to ruminants with no limits. Feeding these varieties to pigs is accepted at a recommended rate of up to 25% but they are not yet recommended for feeding to poultry due to a lack of experimental evidence for safe feeding levels. Both woolly pod vetch varieties, Haymaker and Capello (owned and marketed by Seedmark) have high cyano-glucoside levels. These grains are not recommended for feeding to animals, but there is a strong export market for the seed, especially to Korea for use in government-sponsored programs for green manuring and fertility build-up between rice crops. Vetch hays have been of increasing interest to dairy farmers, especially in irrigation districts where water allocation reductions during the drought have led to new feeding strategies being developed.

The vetch breeding program is currently conducted by Rade Matic of SARDI. It is still a public breeding program that receives support from GRDC and RIRDC, together with some funding of woolly pod vetch evaluation from private seed companies. Breeding objectives for common vetch include low levels of cyanoglucosides in the grain, soft seed and disease control. There is resistance in rust *Uromyces viciae-fabae*; tolerance to ascochyta blight *Ascochyta fabae*; but as yet resistance has yet to be achieved to chocolate spot or grey mould, *Botrytis cinerea* (Nagel 2011). If pregnant cows or sheep graze rust infected vetch then spontaneous abortion can occur, and growers are advised not to feed off rust infected stands, but to plough them in as a green manure crop. There is a further program by Radic/Nagel of SARDI and funded by SAGIT looking at overseas introductions of different vetch types, many of which are showing superior biomass and grain yield (Thomas 2011).

Although there is some royalty capture on vetch seed crops, primarily through the export consignments, much of the Australian domestic market is met by farmer-to-farmer sales which by-pass any royalty system. There has been no practical way of collecting a royalty on vetch used for grazing or green-manuring.

5.3. Capacity for trial grazing evaluation

It is axiomatic that any improvement in currently available dual purpose varieties through strengthened breeding programs and better access to varietal characteristics for farmers, will need continued and likely improved access to in-field experimental grazing capacity. Currently, there is some continued but declining access to evaluation by public research agencies, but increasingly, this work is undertaken by specialist trial evaluation and commercialisation companies working in conjunction with breeders.

5.3.1. Departments of Agriculture / Primary Industries

The **NSW Department of Primary Industry (NSW DPI),** now a component of the NSW Department of Trade and Investment, has played a prominent role in the trialling, evaluation and extension of information relating to dual purpose crop varieties for many years. Results provided guidance on an appropriate method of grazing management in nurseries set up by breeders to select the best dual purpose cereal genotypes for high grain yields. Although crash grazing is unrepresentative of the normal farm practice of extended or continuous grazing with livestock at realistic stocking rates over several weeks, for several years at Temora, 2-3 crash grazing events over 1-2 days were applied to oat selections in the F4 and subsequent generations. The idea was to minimise the selection of herbage by sheep, either preferentially or antagonistically, and thereby create a 'fairer' comparison between genotypes. However, with high densities of livestock grazing for short periods (days instead of weeks), there is a high risk of tiller damage from treading and by eating off the growing point, a loss that may be rapid if stock are left on too long. In defence of crash grazing, the grazing method x genotype interactions that we observed on grain yield were due to the poor performance of the relatively few cultivars that did not possess a proper winter habit, such as Maiden triticale. Crash grazing increases the selection pressure against these unsuitable genotypes.

Furthermore, as in the oat breeding program at Temora, the risks associated with crash grazing can be managed by a system of eating off the nursery only during the day and frequent inspections during grazing, and by avoiding grazing during wet periods. An alternative grazing strategy is to apply 2 cycles of grazing with each cycle comprising 1-2 weeks at a stocking rate of 20 sheep/ha. So long as the final grazing phase extends toward but is completed by the early stem elongation phase (mid-July), there should be good discrimination between genotypes possessing/not possessing a winter habit, and between low and high grain potential.

The capabilities of NSW DPI to continue this work has diminished significantly over the last 5 years due to reduced government funding and perceived high charge-out rates for providing services to breeders. Future trialling capabilities will dependent on the retaining of suitably qualified trialling and extension staff and the availability of research / project dollars to support this capability.

The **Victorian Department of Primary Industries (Vic DPI)** at Kerang (Field Officer Damian Jones) offers some testing and extension support to the **Victorian Irrigated Cropping Council (VICC).** The VICC is a grower organisation that focuses on farm research for the mixed irrigated farming / croppers of northern Victoria at their 74ha farm site near Kerang in Victoria. The VICC, supported by DPI Victoria, has completed many trials assessing the suitability and performance of dual purpose crop varieties over the last 10 years. DPI Victoria has recently ceased providing trial services in a number of regions of Victoria and the local DPI field officer is not certain how long he will be able to offer this service. The VICC plays a prominent role in the activities of the Irrigated Cropping Forum that operates across the irrigated cropping regions of northern Victoria and southern NSW. The dryland Mallee Research Station conducted by DPI Victoria was closed in 2010.

Testing and evaluation of dual purpose crops in Tasmania, being a relatively small market, has traditionally relied on the activities of **the Department of Primary Industries, Parks, Water and Environment (DPIPWE)**. DPIPWE agronomist Geoff Dean had played a major role in managing and the following extension activities from these trials over the past decade or more. Geoff has recently left DPIPWE. Unless a suitable replacement is found, the Tasmanian cropping industry will need to investigate alternative collaborators to perform this role in Tasmania.

The **South Australian Research and Development Institute** undertakes cereal research at the Minnipa Agricultural Centre, which serves the cereal growing (<350 mm p.a.) areas of Eyre Peninsula. It has evaluated dual purpose crops, including cereals, peas and brassicas. It runs a major component of Grain and Graze as well being a prime site for the low rainfall crop sequencing work. The Eyre Peninsula Agricultural Research Foundation (EPARF) is an independent advisory group with 300 grower members providing strategic support and planning for the Centre. EPARF is managed by elected members from the EP farming community and representatives from SARDI and the University of Adelaide. Cereal research is funded through the South Australian government, GRDC and SAGIT.

5.3.2. Farmer Groups

A variety of farmer groups has developed in recent years to examine local agronomic options. These groups have conducted modest replicated trials, made paired paddock comparisons, held field days and have facilitated extension of new technologies into practice. Their endeavours have been integral to raising awareness about dual purpose crops and making knowledge more readily available to their stakeholders. Some of the principal contributors are outlined below.

SOUTHERN VICTORIA / SOUTH EAST SOUTH AUSTRALIA

The **Southern Farming Systems (SFS)** Group has been the major provider of dual purpose crop variety trialling in Southern Victoria, including Gippsland, over the last 15 years. SFS continues to play an important role in such projects as Grain and Graze and the evaluation of winter wheat breeding material from AusGrainz. The recent departure of experienced staff and some difficult production seasons have created some service related issues for this organisation in recent years.

The **MacKillop Farm Management Group** (MFFG) is a regional grower based research organisation that is focused on delivering innovative and sustainable farming practices through research and extension in South East South Australia and western Victoria. Research trials are completed by the SARDI research and extension team based at Naracoorte in South Australia. Dual purpose crop varieties are included in many of the evaluation trials conducted by the MFFG.

The **Southern Grain and Graze 2 coordinators** are predominately conducting a number of large on farm replicated trials to complete their research projects relating to soil structure damage, weed seed banks and disease reduction projects.

NORTHERN VICTORIA

The Birchip Cropping Group (BCG) is a participant in the Graze and Grain 2 project. However, very little of its work involves the evaluation of the specifically bred dual purpose crop varieties, but it contributes to the Crop Sequencing Projects run as part of Low Rainfall Collaboration Projects and Mark Peoples of CSIRO.

The grower managed **Riverine Plains Farming Group** based in North East Victoria conducts a number of trails, including dual purpose variety trials, in north east Victoria and southern NSW. The group has over 300 grower members.

NEW SOUTH WALES

Farmlink Research is a grower, adviser driven farming systems research organisation based at Junee in Southern NSW. Since being established in 2002 Farmlink has completed a significant amount of research work relating to the use of dual purpose crop varieties including being a major participant in Grain and Graze 1 and 2 Projects.

AMPS Research is a grower funded research organisation based on the Liverpool plains of NSW. This organisation, in conjunction with agronomic advisors, identifies and completes research projects important to their grower members. A number of the dual purpose crop varieties have been evaluated for grain yield in their variety trials for a number of years.

The **Monaro Farming Systems Group** of growers has been very helpful in undertaking sampling of experimental plots and forwarding the harvested material to CSIRO Canberra for analysis.

Other groups active in dual purpose crops and systems evaluation include **Mallee Sustainable Farming Inc.**(NSW, Victoria and SA), **Central West Farming Systems** (Condobolin NSW) and **Upper North Farming Systems** (Jamestown, SA). There are several similar groups in Western Australia.

5.3.3. Private trial contractors

Plant breeders are increasingly contracting out aspects of their work, including growing-out of selections, the multiplication of mother seed and yield evaluation trials. There are examples of locations (e.g. Esperance WA), where one contractor has been servicing several discrete breeding programs. There are several providers of services for the evaluation of breeding lines, chemicals and agronomic treatments – examples include those described below:

Agritech is a private crop research company based at Young, Narrabri and Wagg Wagga in NSW, Geelong in Victoria and Naracoorte in South Australian. Agritech is well resourced and respected agricultural research company. The company has been actively involved in completing the evaluation of grazing potential of canola in the southern NSW region.

Agrisearch Services provides independent applied research services, predominantly but not exclusively aimed at the evaluation and development of potential products, crop, plant varieties and technical services. Agrisearch has 13 offices located across Australia with the Orange and Wagga Wagga in NSW and Horsham and Shepparton in Victoria offices being the closest to the key dual purpose cropping zones.

Dodgshun Medlin and **Agrivision** (both based in Swan Hill in NW Victoria) undertake contract research work as well as provide farm consultancy services

5.4. The collection of royalties

Dual purpose crop varieties can generally be grown in mixed farming areas where growers, depending on seasonal conditions, will decide to graze and / or produce grain from these varieties. Grain produced is usually of feed grain quality and is either used on farm or sold to neighbouring farmers or nearby intensive feed grain users, thereby by-passing a major bulk handling receival site. Developing a successful royalty capture scheme for varieties grown in these zones is difficult due to there being limited royalty capture points in the forage, fodder and feed grain markets. In 2008 the Australian plant breeders and seed commercialisers formed an industry End Point Royalty (EPR) Industry Working Group to improve end point royalty compliance. The working group has been successful at improving royalty compliance in a number of regions and market segments over the last 3 years. The EPR working group is currently developing strategies to improve EPR compliance on grain used in the domestic feed grain industries of Australia. Improving EPR compliance from feed grains will improve royalty capture form DPC varieties as the majority of grain produced from DPC varieties is used in the domestic feed industry.

The United Kingdom has had some companies using an area-based royalty scheme because end-point royalty capture on final grain yield is difficult in the UK due to multiplicity of grain buyers. Farmers declare area, seed and seeding rate used from which a yield can be determined as inter-seasonal variability is less than in Australia (McCormack 2011).

Royalties on dual purpose crops were first introduced in Australia on CSIRO's dual purpose wheat varieties. Growers of these varieties were to pay $1.00 per tonne end point royalty on grain and a $55 per tonne seed royalty on seed used for forage. This royalty scheme relied on growers correctly declaring, via a harvest declaration, their use of these varieties. This dual pronged royalty collection system was abandoned in 2005 due to the poor compliance rates and administrative difficulties associated with policing these royalties and replaced with a seed royalty of $50/tonne.

It is possible that global positioning scheme (GPS) monitoring and other similar technologies may make it possible to introduce an equitable area-based royalty system.

The **Australian Exporters Company (AEXCO)** was formed in 2002 by the major hay exporting companies of Australia to support the national hay oat breeders by managing the commercialisation and royalty capture of specifically hay oat varieties. AEXCO was able to create a successful royalty capture point, with the support of all the export hay companies, by identifying the variety being delivered and sold by growers for export hay. Growers selling hay of an AEXCO variety pay a $1.00/tonne end point royalty on hay sold to an export hay company. In contrast royalty capture on hay oat varieties used in the domestic has market in Australia has been very difficult. As a first step in trying to implement a domestic royalty capture system AEXCO introduced a seed royalty of $30/tonne on domestic seed sales of AEXCO varieties in 2011.

Waratah Seeds is the licensee for a number of dual purpose cereal varieties. Different royalty schemes are applied for different varieties. The dual purpose Urambie barley has a seed royalty of $45/tonne. Some triticale varieties have an end point royalty collection system whearas other varieties have an area based royalty scheme ($9/ha). The success of royalty collection on all these varieties is reliant on the accurate returns of growers harvest declaration forms. The Waratah Seeds area based and end point royalty collection systems depend on growers accurately completing annual harvest declaration forms. Waratah's royalty administrator estimated their royalty compliance from the 2010/11 harvest season was approximately 70% for both the area and end point royalty schemes. Area based harvest declarations have recently been distributed to approximately 200 growers recorded as growing these specific Waratah varieties in 2011. Despite Waratah Seeds commitment to the collection of royalties only 15 % of growers have returned their harvest declaration forms by their first due date.

Grower's acceptance of fixed area based royalty scheme, considering Australia's variable climate, can be expected to be difficult. Dual purpose crop breeding programs cannot yet rely on area based royalty schemes as a reliable source of revenue.

Growers growing the Dual purpose milling wheats EGA Wedgetail, Marombi and Naparoo varieties are currently paying respectively a $1.45/tonne, $1.00/tonne and $2.50/tonne grain end point royalty. The EGA Wedgetail and Marombi royalty rates can be considered to be low relative to the end point royalties charged on other varieties and the benefits growers obtain from both and grazing and producing grain from these varieties.

In 2008 **Ausgrainz** (CSIRO and New Zealand Institute for Plant & Food Research Limited) chose **Grainsearch** as their licensee to commercialise their winter wheat program. Grainsearch is a grower owned cereal evaluation and commercialisation company based in South West Victoria. The Grainsearch business model relies on growers, in most cases their grower members, paying end point royalties on varieties they manage. The recently released winter wheat dual purpose variety SQP Revenue has a $75/tonne breeder seed royalty and a $3.50/tonne end point royalty (Ausgrainz share of the total EPR is $2.00/tonne). If the grower owned Grainsearch model proves successful it may attract the interest of other grower owned companies in other dual purpose crop regions to implement more secure royalty collection systems to support the plant breeding programs important to their regions future prosperity.

As with wheat and barley, there is considerable concern about the ability to collect endpoint royalties in triticale. There is currently no ordered system of variety declaration and no audit trail. It is largely an honesty system with an estimated compliance rate of collection of 30 to 50%.

The description above indicates that royalty collection for dual purpose crop varieties has lacked a consistent approach with different royalty collection systems being employed for different varieties and commercialisers. Royalty rates, in general, have also increased significantly over the last decade as breeding programs and commercialisers try to recoup sufficient dollars to maintain their investments in this market.

Breeding companies have particular difficulty in recovering royalties from dual purpose crops particularly in cropping regions where farmers save their seed. For this reason, some companies are no longer involved in producing and marketing dual purpose varieties. Comments were made such as "oat varieties leak over the fence like no other crop" and "we are no longer involved in dual purpose cereals because we cannot see a path to collection of sufficient royalties to justify our investment". This issue of royalties is a major impediment to investment in dual purpose crop breeding and evaluation.

It can be argued that the primary orientation in the development of dual purpose wheats should be to milling varieties. It is noted that milling varieties do capture end-point royalties. The simplest solution may be to have a higher end-point royalty rate for early milling varieties that have dual purpose grazing potential. It is noted that some now have a royalty rate of $3.00 per tonne compare with the rate originally struck for Wedgetail of $1.50 per tonne.

Furthermore, most of the seed companies and all of the breeding companies expressed the view that running grazing and grain recovery trials was very expensive and the cost could not be justified on the basis of current royalty streams. An independent testing system funded by a cross-section of Rural R&D Corporations/Companies is favoured by industry as a means of generating appropriate data for dual purpose crop variety comparisons. The GRDC National Variety Trial program does not currently run dual purpose grazing grain recovery trials. A number of breeding companies run small-scale grazing trials with common grazing of plots or grazing simulation by mowing. The correlation between mowing and sheep grazing is unknown. It was noted that NSW DPI has been conducting a mixed cereal trial for many years. Continued funding of this series of experiments was supported by all of the cereal breeders consulted during the course of this review. Canola breeders and seed companies also favour the establishment of a dual purpose alternative crop independent trial system.

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7. Appendices

ANNEX 1

Crop varieties, with dual use varieties identified (NSW)

Wheat varieties

Variety	Trial type	Sown	Grain type	Habit	DualPurpose	Suggested sowing times: March				April				May				June				Jul		
						1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
AGT_Katanya			Bread wheat	Spring	No																			
AGT_Scythe			Bread wheat	Spring	No																			
Amarok	early-season	before 15 May	Feed	Spring	Dual Purpose?	>	x	x	x	x	x	x	x	<	<									
Anlace			Soft Domestic	Spring	No																			
Annuello			Bread wheat	Spring	No																			
Arrivato			Durum	Spring	No																			
Axe	main-season	after 14 May	Bread wheat	Spring	No										>	>	x	x	x	x				
Babbler			Bread wheat	Spring	No																			
Barham	main-season	after 14 May	Soft Domestic	Spring	No								>	>	x	x	x	<	<					
Baxter	early-season	before 15 May	Bread wheat	Spring	No										>	x	x	x	x	<	<			
Beaufort	early-season	before 15 May	Feed	Spring	Dual Purpose						>	x	x	x	x	<	<							
Bolac	main-season	after 14 May	Bread wheat	Facultative	Opportunistic?						>	x	x	x	x	<	<							
Bowerbird			Bread wheat	Spring	No																			
Bowie	main-season	after 14 May	Soft Domestic	Spring	No								>	>	x	x	x	<	<					
Braewood			Bread wheat	Facultative	Opportunistic?							>	x	x	x	x	<							
Brennan			Feed	Winter	Dual Purpose	>	x	x	x	x	x	x	x	<	<									
Camm			Bread wheat	Spring	No																			
Caparoi	main-season	after 14 May	Durum	Spring	No																			
Carinya			Bread wheat	Spring	No									>	x	x	x	x	<					
Catalina			Bread wheat	Spring	No																			
Chara			Bread wheat	Spring	No																			
CLF_Janz	main-season	after 14 May	Bread wheat	Spring	No																			
Correll	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<							
Crusader	main-season	after 14 May	Bread wheat	Spring	No									>	>	x	x	x	x	<				
Cunningham			Bread wheat	Spring	No																			
Currawong	early-season	before 15 May	Feed	Winter	Dual Purpose				>	x	x	x	x	<	<									
Dakota	main-season	after 14 May	Bread wheat	Spring	No																			
Derrimut	main-season	after 14 May	Bread wheat	Spring	No									>	>	x	x	x	x	<				
Diamondbird			Bread wheat	Spring	No																			
Drysdale			Bread wheat	Spring	No																			
EGA_Bellaroi	main-season	after 14 May	Durum	Spring	No									>	>	x	x	<	<					
EGA_Bounty	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<					
EGA_Burke	early-season	before 15 May	Bread wheat	Spring	No																			
EGA_Eaglehawk	early-season	before 15 May	Bread wheat	Facultative	Opportunistic?						>	x	x	x	x	<	<							
EGA_Gregory			Bread wheat	Spring	No																			
EGA_Hume			Bread wheat	Spring	No																			
EGA_Kidman			Bread wheat	Spring	No																			
EGA_Stampede	main-season	after 14 May	Feed	Spring	No									>	>	x	x	x	x	<				
EGA_Wedgetail	early-season	before 15 May	Bread wheat	Winter	Dual Purpose				>	x	x	x	x	<	<									
EGA_Wentworth	main-season	after 14 May	Bread wheat	Spring	No																			
EGA_Wills	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<							
EGA_Wylie	early-season	before 15 May	Bread wheat	Spring	No									>	x	x	x	x	x	<				
Ellison	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<					
Espada	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<					
Estoc	main-season	after 14 May	Bread wheat	Spring	No																			
Frame			Bread wheat	Spring	No																			
Frelon	early-season	before 15 May	Feed	Winter	Dual Purpose																			
GBA_Hunter	main-season	after 14 May	Feed	Spring	No										>	>	x	x	x	x				
GBA_Ruby	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<					
GBA_Sapphire			Bread wheat	Spring	No																			
Giles	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<							
Gladius	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<							
Guardian			Bread wheat	Spring	No																			
H45			Bread wheat	Spring	No																			
H46			Bread wheat	Spring	No																			
Hornet			Bread wheat	Spring	No																			
Hyperno	main-season	after 14 May	Durum	Spring	No									>	>	x	x	<	<					
Jandaroi	main-season	after 14 May	Durum	Spring	No										>	>	x	x	x	<				
Janz	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<					
Kaika			Durum	Spring	No																			
Kennedy			Bread wheat	Spring	No											>	x	x	x	x	<	<		
Kukri			Bread wheat	Spring	No																			

Wheat varieties

Variety	Trial type	Sown	Grain type	Habit	DualPurpose	Suggested sowing times: March				April				May				June				Jul	
						1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Lang	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
Leichhardt			Bread wheat	Spring	No																		
Lincoln	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
Livingston	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
Longreach Bullet			Bread wheat	Spring	No																		
Lorikeet			ASW Soft	Winter	Dual Purpose																		
Mace			Bread wheat	Spring	No																		
Mackellar	early-season	before 15 May	Feed	Winter	Dual Purpose																		
Magenta			Bread wheat	Spring	No																		
Mansfield	early-season	before 15 May	Feed	Winter	Dual Purpose																		
Marombi			Bread wheat	Winter	Dual Purpose		>	>	x	x	x	x	x	x	x	<							
Merinda	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
Naparoo	early-season	before 15 May	Feed	Winter	Dual Purpose																		
Orion	main-season	after 14 May	Soft Domestic	Spring	No								>	>	x	x	x	<	<				
Pardalote			Bread wheat	Winter	Dual Purpose		>	>	x	x	x	x	x	x	x	<							
Peake	main-season	after 14 May	Bread wheat	Spring	No									>	>	x	x	x	x	<			
Petrel			Bread wheat	Hay Wheat	No								>	>	x	x	x	<	<				
Petrie			Bread wheat	Spring	No																		
Preston	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<						
Pugsley	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
QAL2000	main-season	after 14 May	Soft Domestic	Spring	No								>	>	x	x	x	<	<				
QAL3362			Soft Domestic	Spring	No																		
QALBis			Soft Domestic	Spring	No									>	x	x	x	x	<				
Rees			Bread wheat	Spring	No																		
Rosella	early-season	before 15 May	ASW Soft	Winter	Dual Purpose				>	x	x	x	x	<	<								
Rudd	early-season	before 15 May	Feed	Winter	Dual Purpose																		
Saintly			Durum	Spring	No																		
Scout			Bread wheat	Spring	No																		
Sentinel_3R	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<						
Snipe			Soft Domestic	Winter	Dual Purpose						>	x	x	x	x	x	<	<					
Spitfire	main-season	after 14 May	Bread wheat	Spring	No									>	>	x	x	x	x	<			
SQP_Revenue	early-season	before 15 May	Feed	Winter	Dual Purpose																		
Strzelecki	main-season	after 14 May	Bread wheat	Spring	No								>	x	x	x	<						
Sunbri	early-season	before 15 May	Bread wheat	Facultative	Opportunistic?						>	>	x	x	x	x	<	<					
Sunbrook			Bread wheat	Facultative	Opportunistic?						>	x	x	x	<	<							
Sunco	main-season	after 14 May	Bread wheat	Spring	No									>	x	x	x	x	x	<			
Sunlin			Bread wheat	Spring	No								>	x	x	x	x	<					
Sunsoft 98			ASW Soft	Winter	Dual Purpose																		
Sunstate			Bread wheat	Spring	No																		
Sunvale	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
Sunvex	main-season	after 14 May	Bread wheat	Spring	No								>	>	x	x	x	<	<				
Sunzell	early-season	before 15 May	Bread wheat	Spring	No								>	x	x	x	<						
Tamaroi			Durum	Spring	No																		
Tennant	early-season	before 15 May	Feed	Winter	No																		
Thornbill			Soft Domestic	Winter	Dual Purpose																		
Tjilkuri			Durum	Spring	No																		
Ventura	main-season	after 14 May	Bread wheat	Spring	No									>	>	x	x	x	x	<			
Waagan	main-season	after 14 May	Bread wheat	Spring	No										>	>	x	x	x	x			
Whistler			Bread wheat	Winter	Dual Purpose																		
Wollaroi	main-season	after 14 May	Durum	Spring	No																		
Wyalkatchem			Bread wheat	Spring	No																		
Wylah			Bread wheat	Winter	Dual Purpose																		
Yallaroi			Durum	Spring	No											>	x	x	x	x	x	<	<
Yenda	main-season	after 14 May	Soft Domestic	Spring	No						>	x	x	x	x	<	<						
Yitpi	main-season	after 14 May	Bread wheat	Spring	No																		
Young	main-season	after 14 May	Bread wheat	Spring	No									>	>	x	x	x	x	<			
Zebu			Feed	Spring	No								>	>	x	x	x	<	<				
Zulu			Feed wheat	Spring	No								>	>	x	x	x	<	<				

Source: Winter Crop Variety Sowing Guide, 2011, NSW

Barley varieties

Variety	DualPurpose	March				April				May				June				Jul		
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Baudin	No							>	>	x	x	x	x	x	x	<	<			
Binalong	No							>	x	x	x	x	<							
Buloke	No									>	x	x	x	x	x	x	x	<	<	
Capstan	No							>	>	x	x	x	x	x	x	<	<			
Commander	No									>	x	x	x	x	x	x	x	<	<	
Cowabbie	No							>	>	x	x	x	x	x	x	<	<			
Fairview	No							>	x	x	x	x	<							
Fitzroy	No									>	>	x	x	x	x	x	x	<	<	
Flagship	No									>	x	x	x	x	x	x	x	<	<	
Fleet	No									>	x	x	x	x	x	x	x	<	<	
Gairdner	No							>	>	x	x	x	x	x	x	<	<			
Grimmett	No									>	x	x	x	x	x	<				
Grout	No									>	>	x	x	x	x	x	x	<	<	
Hindmarsh	No									>	x	x	x	x	x	x	x	<	<	
Mackay	No									>	x	x	x	x	x	<				
Oxford	No							>	>	x	x	x	x	x	x	<	<			
Schooner	No									>	x	x	x	x	x	x	x	<	<	
Scope	No									>	x	x	x	x	x	x	x	<	<	
Shepherd	No									>	x	x	x	x	x	x	x	<	<	
Sloop_Vic	No									>	x	x	x	x	x	x	x	<	<	
Tantangara	No							>	>	x	x	x	x	x	x	<	<			
Tilga	No									>	>	x	x	x	x	x	x	<	<	
Tulla	No									>	>	x	x	x	x	x	x	<	<	
Urambie	DualPurpose		>	x	x	x	x	x	x	x	x	<								
Vlamingh	No							>	>	x	x	x	x	x	x	<	<			
Westminster	No							>	x	x	x	x	<							
Yambla	DualPurpose		>	x	x	x	x	x	x	x	x	<								
Yarra	No							>	>	x	x	x	x	x	x	<	<			

Source: Winter Crop Variety Sowing Guide, 2011, NSW

Triticale varieties

Variety	Dual Purpose		ebrua		March				April				May				June				July	
			3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Berkshire	Grain Only												>	x	x	x	x	x	<			
Bogong	Grain Only																					
Breakwell	Dual-purpose	Outclassed, stripe rust			>	x	x	x	x	x	<	<										
Canobolas	Grain Only	Outclassed, stripe rust											>	x	x	x	x	x	<			
Chopper	Grain Only													>	>	x	x	x	x	x	<	<
Crackerjack	Dual-purpose										>	x	x	x	x	x	x	<				
Credit	Grain Only	Outclassed, stripe rust											>	x	x	x	x	x	<			
Endeavour	Dual-purpose		>	x	x	x	x	x	x	x	<	<										
Hawkeye	Grain Only												>	x	x	x	x	x	<			
Jaywick	Grain Only												>	x	x	x	x	x	<			
Kosciuszko	Grain Only	Outclassed, stripe rust											>	x	x	x	x	x	<			
Rufus	Grain Only												>	x	x	x	x	x	<			
Speedee	Grain Only	Outclassed, stripe rust												>	>	x	x	x	x	x	<	<
Tahara	Grain Only	Outclassed, stripe rust											>	x	x	x	x	x	<			
Tickit	Grain Only	Outclassed, stripe rust											>	x	x	x	x	x	<			
Tobruk	Grain Only	Outclassed, stripe rust		>	x	x	x	x	x	x	x	x	x	x	x	x	<					
Tuckerbox	Dual-purpose	Limited data available in NSW																				
Yukuri	Grain Only												>	x	x	x	x	x	<			

Source: Winter Crop Variety Sowing Guide, 2011, NSW

Oat varieties

Variety	Use	Jan 1	Jan 2	Jan 3	Jan 4	Feb 1	Feb 2	Feb 3	Feb 4	March 1	March 2	March 3	March 4	April 1	April 2	April 3	April 4	May 1	May 2	May 3	May 4	June 1	June 2	June 3
Barcoo	Hay, silage, forage																							
Bass	Dual-purpose	>	x	x	x	x	x	x	x	x	x	<	<											
Bimbil	Dual-purpose	>	x	x	x	x	x	x	x	x	x	<	<											
Blackbutt	Dual-purpose							>	x	x	x	x	<	<	<	<								
Brusher	Specialist hay																							
Cooba	Dual-purpose																	>	x	x	x	x	x	<
Coolabah	Dual-purpose											>	x	x	x	x	x	<	<	<				
Culgoa II	Hay, silage, forage																							
Dawson	Hay, silage, forage																							
Drover	Hay, silage, forage																							
Enterprise	Hay, silage, forage																							
Eurabbie	Dual-purpose																	>	x	x	x	x	x	<
Galileo	Hay, silage, forage																							
Genie	Hay, silage, forage																							
Graza 50	Hay, silage, forage																							
Graza 51	Hay, silage, forage																							
Graza 68	Hay, silage, forage																							
Graza 80	Hay, silage, forage																							
Gwydir	Hay, silage, forage																							
Kangaroo	Specialist hay																							
Lordship	Hay, silage, forage																							
Mannus	Dual-purpose										>	x	x	x	x	x	x	<	<	<				
Mitika	Grain only																	>	x	x	x	x	<	<
Moola	Hay, silage, forage																							
Mortlock	Grain only																	>	x	x	x	x	x	<
Nile	Dual-purpose	>	x	x	x	x	x	x	x	x	x	<	<											
Nugene	Hay, silage, forage																							
Possum	Grain only																	>	x	x	x	x	<	<
Quamby	Hay, silage, forage																							
Saia	Hay, silage, forage																							
Taipan	Hay, silage, forage																							
Tammar	Specialist hay																							
Tungoo	Specialist hay																							
Volta	Hay, silage, forage																							
Warrego	Hay, silage, forage																							
Wintaroo	Specialist hay																							
Yallara	Grain only																	>	x	x	x	x	<	<
Yarran	Dual-purpose											>	x	x	x	x	x	<	<	<				
Yiddah	Dual-purpose										>	x	x	x	x	x	x	<	<	<				

Source: Winter Crop Variety Sowing Guide, 2011, NSW

CANOLA Varieties

Variety	Herbicide class	Maturity group	Comment	Suggested sowing times															
				March				April				May				June			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
43C80(CL)	CLEARFIELD®	Early								>	x	x	x	<	<				
44Y84(CL)	CLEARFIELD®	Early to early–mid								>	x	x	x	<	<				
45Y21(RR)	Roundup Ready®	Mid–early	Hybrid							>	x	x	x	<	<	<			
45Y22(RR)	Roundup Ready®	Mid–early	Hybrid							>	x	x	x	<	<	<			
45Y82(CL)	CLEARFIELD®	Early–mid								>	x	x	x	<	<				
46Y20(RR)	Roundup Ready®	Mid	Hybrid							>	x	x	x	<	<	<			
46Y83(CL)	CLEARFIELD®	Mid to mid–early								>	x	x	x	<	<				
ATR–Cobbler	Triazine tolerant	Early to mid–early								>	x	x	x	<	<				
ATR–Snapper	Triazine tolerant	Early–mid								>	x	x	x	<	<				
ATR–Stingray	Triazine tolerant	Early								>	x	x	x	<	<				
AV–Garnet	Conventional	Mid to mid–early								>	x	x	x	<	<				
CB Agamax	Conventional	Early–mid								>	x	x	x	<	<				
CB Argyle	Triazine tolerant	Mid								>	x	x	x	<	<				
CB Eclipse RR	Roundup Ready®	Early to mid	Hybrid							>	x	x	x	<	<	<			
CB Jardee HT	Triazine tolerant	Mid	Hybrid							>	x	x	x	<	<				
CB Junee HT	Triazine tolerant	Early–mid	Hybrid							>	x	x	x	<	<				
CB Mallee HT	Triazine tolerant	Early–mid	Hybrid							>	x	x	x	<	<				
CB Scaddan	Triazine tolerant	Mid								>	x	x	x	<	<				
CB Tanami	Triazine tolerant	Early								>	x	x	x	<	<				
CB Taurus	Conventional	Winter	Very late maturity, Dual purpose, marketed in 60							?									
CB Telfer	Triazine tolerant	Very early								>	x	x	x	<	<				
CB Tumby HT	Triazine tolerant	Early–mid to mid								>	x	x	x	<	<				
Crusher TT	Triazine tolerant	Mid								>	x	x	x	<	<				
Fighter TT	Triazine tolerant	Early to mid–early								>	x	x	x	<	<				
GT Cougar	Roundup Ready®	Mid	Open-pollinated							>	x	x	x	<	<	<			
GT Mustang	Roundup Ready®	Mid–late	Open-pollinated							>	x	x	x	<	<	<			
GT Scorpion	Roundup Ready®	Early	Open-pollinated							>	x	x	x	<	<	<			
GT Taipan	Roundup Ready®	Early	Open-pollinated							>	x	x	x	<	<	<			
GT61	Roundup Ready®	Early–mid								>	x	x	x	<	<	<			
Hyola® 404RR	Roundup Ready®	Mid–early	Hybrid							>	x	x	x	<	<	<			
Hyola® 433	Conventional	Early–mid	Hybrid							>	x	x	x	<	<				
Hyola® 444TT	Triazine tolerant	Early	Hybrid							>	x	x	x	<	<				
Hyola® 50	Conventional	Mid to mid–early								>	x	x	x	<	<				
Hyola® 502RR	Roundup Ready®	Early–mid	Hybrid							>	x	x	x	<	<	<			
Hyola® 505RR	Roundup Ready®	Mid to mid–early	Hybrid							>	x	x	x	<	<	<			
Hyola® 555TT	Triazine tolerant	Mid–early	Hybrid							>	x	x	x	<	<				
Hyola® 571CL	CLEARFIELD®	Early–mid	Hybrid							>	x	x	x	<	<				
Hyola® 575CL	CLEARFIELD®	Mid to mid–early	Hybrid							>	x	x	x	<	<				
Hyola® 601RR	Roundup Ready®								?										
Hyola® 606RR	Roundup Ready®	Mid to mid–late	Hybrid							>	x	x	x	<	<	<			
Hyola® 676CL	CLEARFIELD®	Mid–late	Hybrid							>	x	x	x	<	<				
Monola™ 603TT	Triazine tolerant	Mid								>	x	x	x	<	<				
Monola™ 704TT	Triazine tolerant	Mid to mid–late								>	x	x	x	<	<				
Monola™ 76TT	Triazine tolerant	Mid								>	x	x	x	<	<				
Monola™ 77TT	Triazine tolerant	Mid								>	x	x	x	<	<				
Oasis CL	CLEARFIELD®	Early	Juncea							>	x	x	x	<	<				
Tawriffic TT	Triazine tolerant	Mid–early								>	x	x	x	<	<				
Thumper TT	Triazine tolerant	Mid to mid–late	Double haploid							>	x	x	x	<	<				
Victory V3001	Conventional	Early–mid								>	x	x	x	<	<				
Victory V5001	Roundup Ready®	Early–mid	Specialty (HOLL), hybrid							>	x	x	x	<	<	<			

Source: Winter Crop Variety Sowing Guide, 2011, NSW

ANNEX 2

GRDC PROJECT INFORMATION: DUAL PURPOSE CROPS

Since 2002 GRDC has invested in several projects across two Lines of Business (Varieties and Practices) on management and breeding of dual purpose crops. Project titles and investment allocations are included in the budget spreadsheet below

INDIVIDUAL PROJECTS

CSP00101	Breeding dual purpose feed wheats for the High Rainfall Zones
US00049	The National Triticale Improvement Program
CSP00132	Optimising the integration of dual purpose crops in the higher rainfall zone
CSP00085	Evaluating the potential for dual purpose canola in the mixed farming system of southern Australia
CSP00009	Increasing farm profits in the high rainfall zone using mixed cropping and grazing
CSP00097	Managing crops, animals and disease in mixed farming systems based on dual purpose wheats

PROJECT BUDGETS:

Project ID	2002-2003	2003-2004	2004-2005	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
CSP00101								$325,000	$325,000
US00049								$198,500	$198,500
CSP00132							$ 256,634	$ 348,216	$ 295,150
CSP00085				$ 150,000	$ 150,000	$ 175,000			
CSP00009	$ 129,752	$ 122,369	$ 192,256	$ 85,000					
CSP00097				$ 65,000	$ 150,000	$ 150,000			
Total	**$ 129,752**	**$ 122,369**	**$ 192,256**	**$ 300,000**	**$ 300,000**	**$ 325,000**	**$ 256,634**	**$ 871,716**	**$ 493,650**

Total expenditure of $2 991 377 over 10 year period

ANNEX 3

THE REVIEW TEAM

Skill Base	Personnel
Panel Chair	Dr John Radcliffe AM FTSE, Honorary Research Fellow, CSIRO, Waite Campus, Glen Osmond, SA
Breeding	Dr Peter Martin, Research Agronomist, Industry & Investment NSW, Wagga Wagga, NSW
Practices	Emeritus Professor Ted Wolfe, Charles Sturt University, Wagga Wagga NSW
Business	Denis McGrath, Seedvise Pty Ltd, Newtown, Vic
Livestock	Dr Hugh Dove, FAIAST, FASAP, Research Scientist, CSIRO Plant Industry, Canberra, ACT

ANNEX 4

Grains Research & Development Corporation (GRDC) has sent you this email.
To ensure you don't miss future email updates,
please add **subscribers@grdcsubscribers.com.au** to your email address book or safe list.

GRDC Grains Research & Development Corporation

Dual Purpose Cropping Survey

www.grdc.com.au

Tom

You have been identified by the GRDC as a grain grower.

The GRDC are currently reviewing the use of dual purpose crops nationally to shape future strategic investment in this area. By participating in this short survey, you will help the development of a draft report highlighting the current needs of mixed farmers using dual purpose crops.

If you would like to receive an email copy of the draft report in early September, please ensure you tick the box at the end of the survey.

Click here to commence the GRDC's Dual Purpose Cropping Survey (close date 4th July 2011).

Tom Giles
Project Manager - Plant Breeding

If you are not a grain grower, please **click here to email us** & we will update our records.

Grains Research & Development Corporation

Dual Purpose Cropping Survey

Dual Purpose Crops Farmer Survey Questions

1. What is your property postcode(s)?

2. What is the size of your farm(s)? State area 00Ha

1. Have you grazed any crops in the last 3 years?
   Yes
   No- please go to question 8

2. Giving a percentage value, rank the following crops by their use for grazing on your property over the last 3 years. (Must add up to 100%)
   i. Wheat 00%
   ii. Barley 00%
   iii. Oats 00%
   iv. Triticale 00%
   v. Vetch 00%
   vi. Canola 00%

4. In the last 3 years what percentage of varieties grazed were specific dual purpose*(see table for examples), standard grain or forage varieties?
   i. Dual Purpose 000%
   ii. Grain 000%
   iii. Forage 000%

Dual Purpose variety examples:

Wheat: Amarok, Beaufort, Brennan, Currawong, EGA_Wedgetail, Frelon, Mackellar, Mansfield, Marombi, Naparoo, Rudd, SQP_Revenue, Tennant.

Barley: Urambie and Yambla

Oats: Bass, Bimbil, Blackbutt, Cooba, Eurabbie, Mannus, Nile, Yarran, Yiddah

Triticale: Breakwell, Crackerjack, Endeavour, Tobruk, Tuckerbox

5. When planting any of these crops did you intend to graze or was grazing done opportunistically as the season progressed?

   i. Planned to graze when planting
   ii. Opportunistically grazed as season progressed
   iii. Both – what percentage was planned 000

6. What was the main driver behind the decision to graze? (select one)
    a. Grain price
    b. Sowing window
    c. Needed the feed
    d. The need to rest or establish pasture paddocks
    e. The need to manipulate crop growth stages

7. After being used for grazing what percentage of the crops ended up:
    i. Harvested for delivery
    ii. Harvested for use on farm
    iii. Cut for Hay or Silage
    iv. Grazing continued

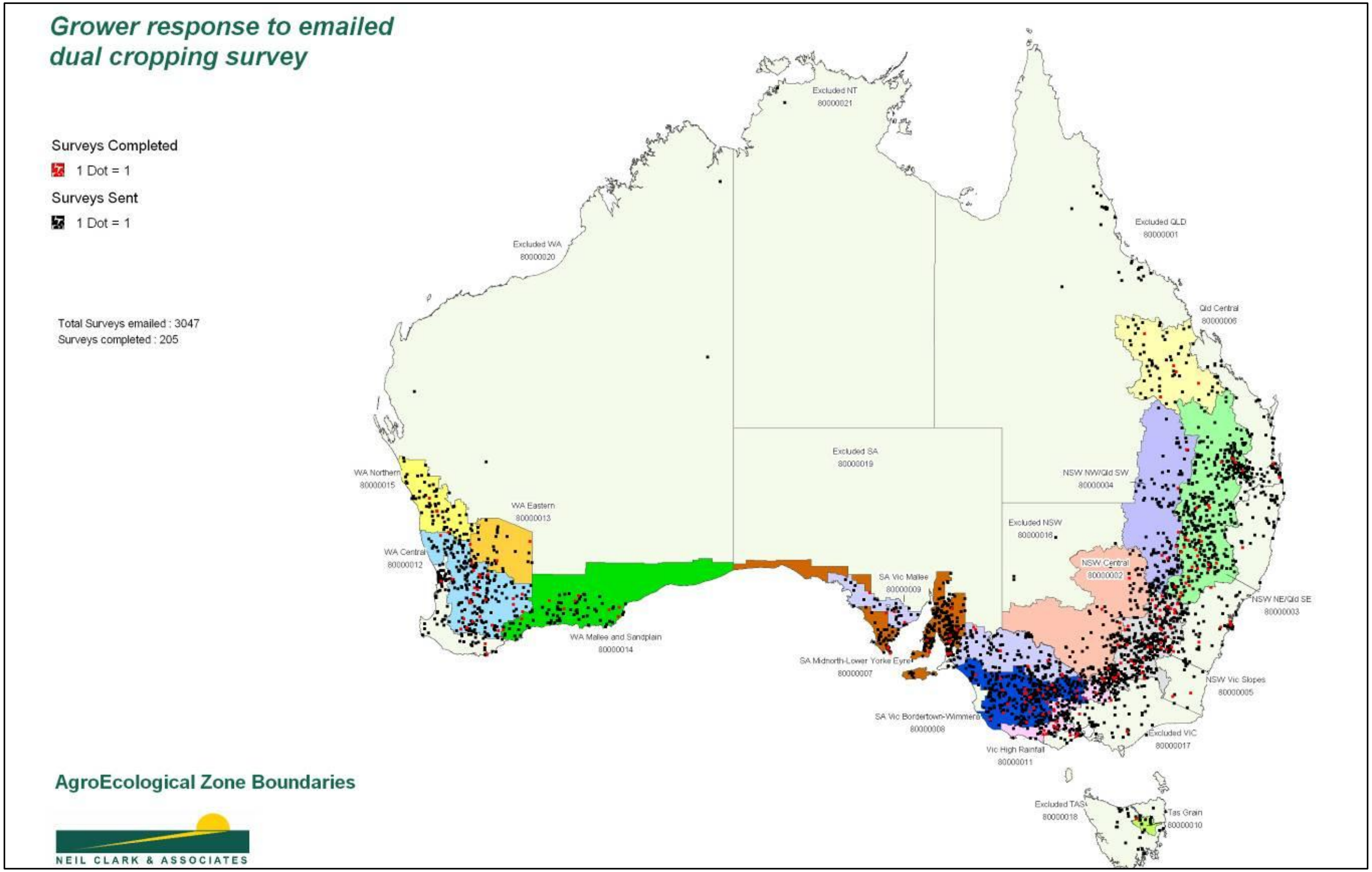
8. What are the major issues limiting the use of dual purpose crops on your farm? (Choose 3 options and list in order of importance i.e. 1, 2, 3)
    i. Potential loss of grain yield
    ii. No milling quality variety available for my environment
    iii. Disease classification of current varieties
    iv. Additional feed not required for livestock
    v. Not confident in integrating livestock in grain production systems
    vi. Lack of suitable varieties for my rainfall zone
    vii. Livestock nutrition concerns

9. Given a preference where would you see investment in dual purpose crops? (select 2)
    i. Research into developing new dual purpose specific varieties
    ii. Development of grain varieties that recover better from grazing
    iii. Extend more information on how to graze crops using established guidelines
    iv. Continue research in the medium to low rainfall environments on how to best graze grain crops
    v. Continued regional evaluation of dual purpose crops
    vi. None, direct money to other research priorities

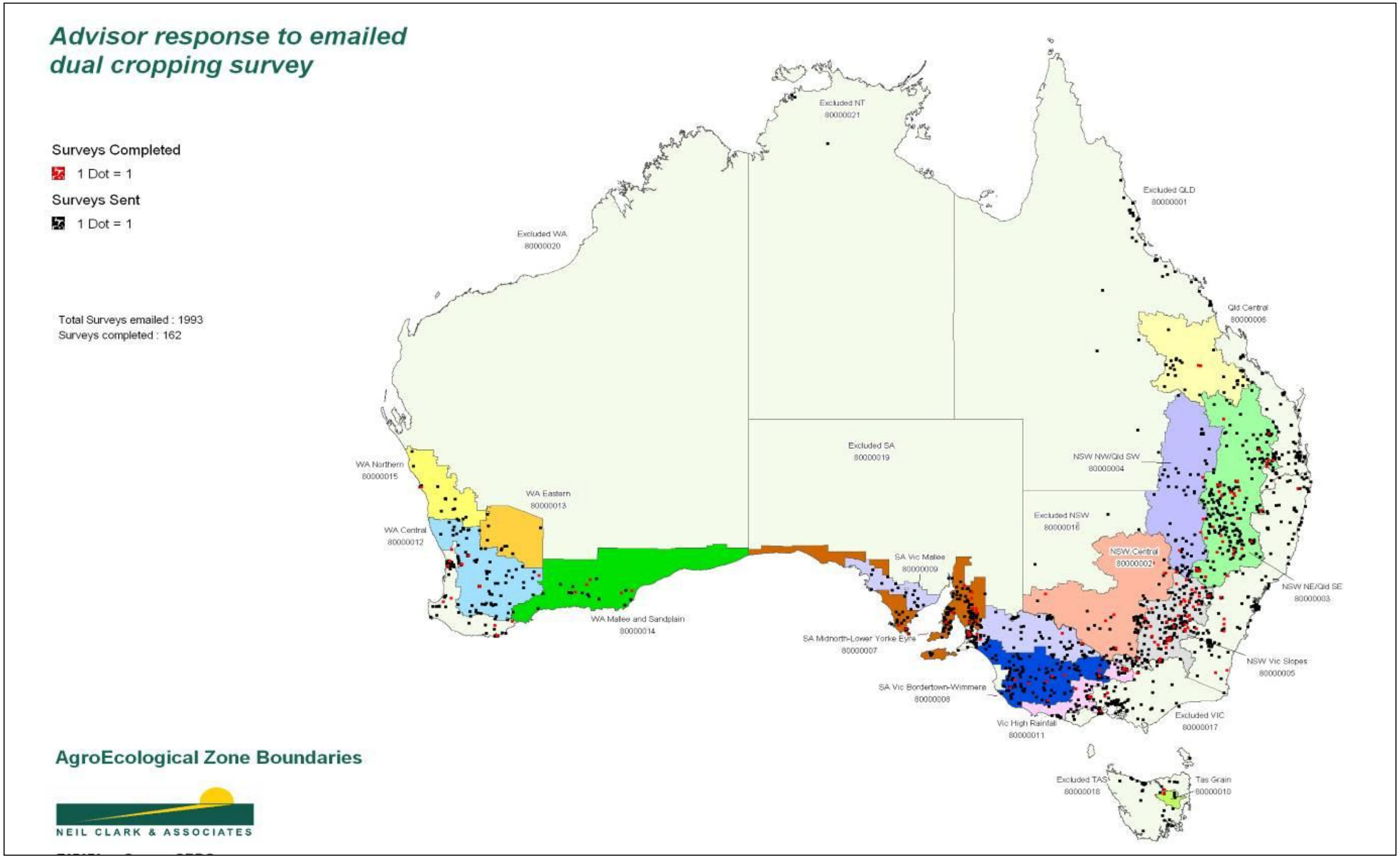
If there is any further information that you would like to provide for this review please use the section below.

☐ Please tick this box if you would like to receive an advanced draft copy of the review document for your comments.

Distribution of survey invitations to growers and advisers (black dots) and responses received (red dots) **ANNEX 5**



Distribution of survey invitations to growers and advisers (black dots) and responses received (red dots) **ANNEX 6**



ANNEX 6

GLOSSARY

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences – a unit within the Commonwealth Department of Agriculture, Fisheries and Forestry
ABS	Australian Bureau of Statistics
ACRCP	GRDC Australian Cereal Rust Control Program
AEXCO	Australian Exporters Company, a company formed in 2002 by the major hay exporting companies of Australia to support the national hay oat breeders by managing the commercialisation and royalty capture of specific hay oat varieties.
AGT	Australian Grain Technologies Pty Ltd, a wheat breeding company whose shareholders include GRDC, SARDI, University of Adelaide, Vilmorin & Cie (a wholly owned subsidiary of Limagrain Holdings), and has merged with Sunprime Seeds, developed a partnership with the Council of Grain Grower Organisations (WA) and had acquired the licence to the former Enterprise Grain Australia germplasm.
AusGrainz	A company initially formed by an alliance between CSIRO Plant Industry and New Zealand's Plant & Food Research Crown Research Institute.
AWB Seeds	A company owned by Landmark
AWI	Australian Wool Innovation Ltd
BCG	Birchip Cropping Group, a not-for-profit agricultural research and extension (communication) organisation led by farmers from the Mallee-Wimmera region of Victoria.
BYDV	Barley Yellow Dwarf Virus
CSIRO	Commonwealth Scientific and Industrial Research Organisation
cv.	cultivar
DEEDI	Queensland Department of Employment, Economic Development and Innovation
DM	dry matter
DPI	Department of Primary Industries (several states)
DSE	dry sheep equivalent
dual purpose crops	Varieties (plant genotypes) that can be sown early and are protected from early reproductive development due to the presence of genes that must be triggered by photoperiod (the winter solstice is important) and/or cold (vernalisation).
dual purpose spring crop	A "spring" crop with a classification of "dual purpose" is a genotype in which floral initiation appears to be controlled by a photoperiodic stimulus rather than by a vernalisation (cold) stimulus or both stimuli. Such a variety can be sown earlier than mainstream varieties (but refer to the recommended sowing time).
dual purpose winter crop	A "winter" crop with a classification of "dual purpose" is a genotype in which floral initiation seems to be controlled a vernalisation (cold) stimulus, or a combination of both stimuli (photoperiod and cold). Such varieties can be safely sown early without premature floral initiation occurring.
EGA	Enterprise Grains Australia, which was a joint venture between the Queensland Department of Primary Industries and Fisheries, NSW DPI and the GRDC.
EPARF	Eyre Peninsula Agricultural Research Foundation
EPR	end point royalties
GM	genetically modified crops

GPS	global positioning system
GRDC	Grains Research and Development Corporation
ha	hectare
HRZ	high rainfall zone; also HRZ Wheats Pty Ltd, a specialised wheat breeding company originally set up by the Ausgrainz partners and GRDC, subsequently joined by Landmark.
IP	intellectual property
K	potassium
Mainstream variety	This term refers to crop varieties that are sown during the peak sowing period for grain production. They are sometimes grazed opportunistically.
MAS	marker assisted selection
MFFG	MacKillop Farm Management Group, a regional grower based research organisation that delivers research and extension in the South East region of South Australia and western Victoria.
Mg	magnesium
MgO	magnesium oxide
MgSO4	magnesium sulphate
MLA	Meat and Livestock Australia Ltd
Na	sodium
NOBP	GRDC National Oat Breeding Program
NSW	New South Wales
PDPIWE	Tasmanian Department of Primary Industries, Parks, Water and Environment
P/E ratio	the ratio of precipitation (P = median monthly rainfall) to evaporation (E = potential monthly evaporation)
PSR	pasture stocking rates
RD&E	research, development and extension
RIRDC	Rural Industries Research and Development Corporation
SA	South Australia
SAGIT	South Australian Grains Industry Trust – funded through a voluntary levy paid by South Australian grain growers
SARDI	South Australian Research and Development Institute
SE	south-east
SFS	Southern Farming Systems Group, which undertakes crop variety trials in southern Victoria
single purpose spring crop	A ‘spring’ crop unsuitable for dual purpose cropping use and has a genotype in which floral initiation seems to be a function of growing day degrees (warmth), and so it is unsuitable for early sowing.
TT	Triazine tolerant varieties of canola (tolerant to triazine herbicides)
USA	United States of America
VICC	Victorian Irrigated Cropping Council, which is a grower organisation that undertakes on-farm research for the mixed irrigated farming / croppers of northern Victoria on a 74ha site near Kerang.
WA	Western Australia
WSMV	Wheat Streak Mosaic Virus