OVERVIEW-FROM SEED TO SUCCESS

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INTRODUCTION

In a survey of participants at the inaugural conference of the Grassland Society of NSW, 88 and 79 per cent of respondents agreed that renovation and establishment respectively should be the topics covered in this year's conference. The Committee of the Society has responded and formulated the program "Pasture Establishment and Renovation-Today and Tomorrow". It is a very timely choice. Let me briefly outline why.

The Australian sheep flock is projected to be around 170 million by March 1991 (BAE, 1987), only 10 million short of the record 1970 numbers. If cattle numbers remain static this will push total grazing livestock, in sheep equivalents (table 1), to 356.4 million, the highest since the mid 1970's when the area of sown improved pasture was also at its peak. There is every indication that the area of improved pasture has remained static or declined in the 1980's (table 1); between 1979 and 1982 the sown pasture area on the Central and Southern Tablelands of NSW fell by 17 per cent. Given that application of superphosphate also declined in the 1980's it is fairly safe to conclude that pasture productivity is declining at a time when grazing pressure (the mass of animals per unit of available pasture) is increasing.

These figures provide a national and state view but how will this trend impact at the level of individual farms? Will farmers accept lowered productivity or invest in technology to improve productivity, or to sustain productivity at current levels? Or alternatively do we have some room to manoeuvre because of our traditionally conservative stocking rates? These are questions for which I do not have a clear answer, but they emphasise the importance of the conference we are starting today. Clearly pasture establishment and renovation are issues which are going to have to be faced today or tomorrow by managers of grazing enterprises. These managers will frequently start the task with seed and, hopefully, conclude with success.

Seed is both the start and the end of the life cycle of most pasture plants. This life cycle involves germination, emergence, survival and growth, establishment of a new population of productive parent plants, appropriate management to maintain a desired plant population, flowering, further seed formation and return of this seed to the soil.

Success, is the necessary end point for farmers managing each of the above stages in conjunction with the animals that will graze the pasture. Success is not guaranteed in pasture establishment and renovation in much of the Australian environment. To manage this process many variables and their interactions must be taken into account.

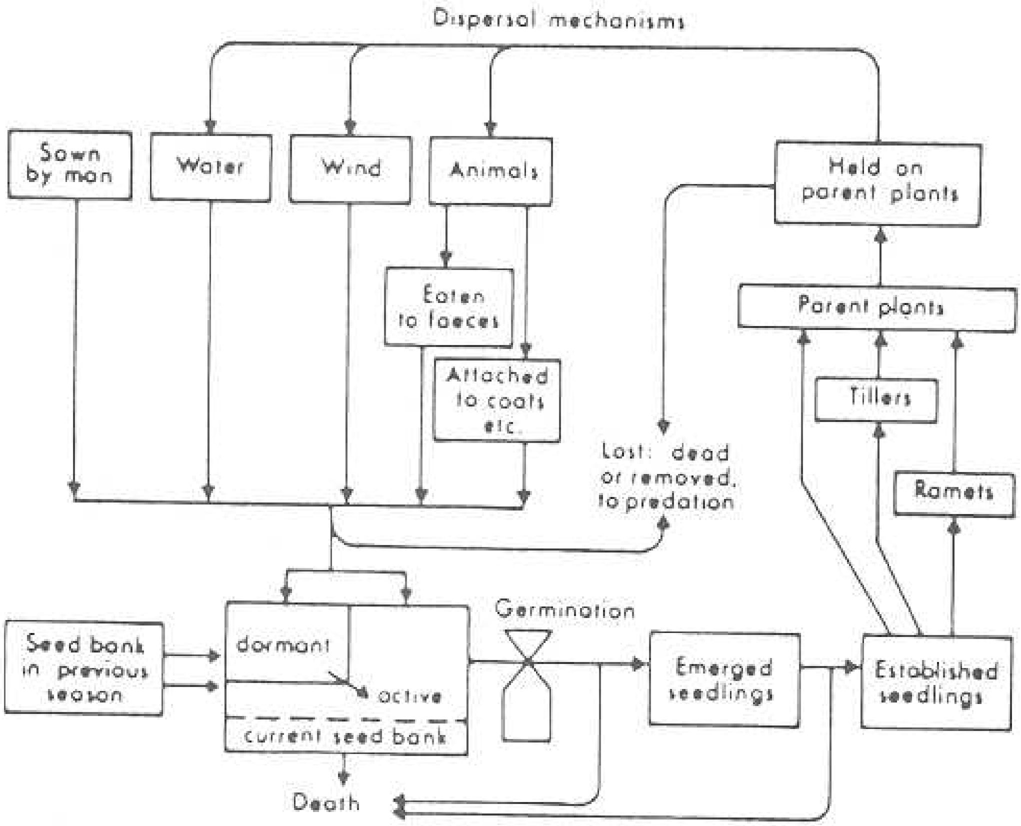
TABLE 1 Trends in the broadacre agricultural industries: Australia and NSW

Year	Sheep numbers AUST.	Sheep numbers NSW	Cattle numbers AUST.	Cattle numbers NSW	Total Livestock in sheep equivalents* AUST.	Total Livestock in sheep equivalents* NSW	Area of improved pasture (ha) AUST.	Area of improved pasture (ha) NSW
	'000	'000	'000	'000	'000	'000	'000	'000
1950-51	115 596	-	15 229	-	237 428	-	7 325	-
1955-56	139 124	-	16 457	-	270 780	-	11 250	-
1960-61	152 679	-	16 332	-	291 335	-	14 402	-
1965-66	157 563	-	17 936	-	301 051	-	19 635	-
1970-71	177 792	-	24 373	-	372 776	-	28 031	-
1975-76	148 644	53 200	33 434	8 900	416 116	124 400	27 707	5 838
1980-81	134 407	46 000	25 168	5 270	335 751	88 160	24 911	5 180
1981-82	137 980	48 700	24 550	5 273	334 380	90 844	n.a.	4 723
1982-83	133 240	48 095	22 480	4 873	313 080	87 079	n.a.	4 576
1983-84	139 240	50 997	22 160	4 990	316 520	90 917	n.a.	4 379
1984-85	150 760	55 495	23 030	5 093	335 000	96 239	n.a.	5 142
1985-86	157 570	58 001	23 260	5 410	341 650	101 281	n.a.	5 440
1986-87	160 000	n.a.	23 300	n.a.	346 400	n.a.	n.a.	n.a.

* 1 cattle = 8 sheep
n.a. = not available.

Source: Menz 1984, BAE 1987 and ABS.

FIGURE 1: A model to partially describe pasture generation dynamics from seed and vegetative propagules.



Source: Pearson and Ison (1987)

To do this some conceptual understanding of the biological, economic and engineering criteria on which decisions must be based is needed. One of the later speakers (Dick Ord,) would appear to have taken most of these variables into account and still only claims a 70 per cent success rate. I would hope that this overview, the papers to follow and the discussion generated during our two days together will provide the necessary information for us all to seek new, better and more cost-effective pathways to success in pasture establishment and regeneration. After all we need success today to give us a fighting chance tomorrow!

SEED OR PARENT PLANTS - THE STARTING POINT

Two potential starting points exist based on an initial decision as to whether to establish a new pasture or renovate an old one. These are not always mutually exclusive and there exists a continuum of technology and management ranging from regenerating an old pasture to establishing a new pasture. The decision of where to operate in this continuum will vary with individual farm or paddock and farmer circumstance but all will involve attempting to change the existing species balance and plant population whether these are trees, shrubs, native, naturalised or 'improved' pastures.

Let us take the parent plant, or more strictly a population of parent plants (a pasture) as the starting point. Figure 1 describes pasture generation dynamics from seed and vegetative material; the pathways described are the basis of the ecological adaptation of many of our pasture plants, particularly Mediterranean annual legumes and grasses such as subclover or annual ryegrass. Many native and naturalised species have similar pathways for survival. The major exceptions of course are the main perennial species such as lucerne, red clover and to a lesser extent phalaris and fescue which under grazing do not readily regenerate from seed inputs into the soil seed bank. Phalaris and fescue have the advantage of spreading vegetatively through short rhizomes. The other exception is where economic returns enable annual resowing of pastures with annual species which do not readily regenerate from seed (e.g. berseem clover or some of the tetraploid Italian ryegrasses) or which are not allowed to do so. A later speaker, Liz Kernohan discusses this in more detail.

The cycle (figure 1) may be traced thus:-

(i) An initial population of parent plants which may comprise varying proportions of desirable and non-desirable species with different flowering and seed producing characteristics. There is a need, particularly for pastures based on annual species, to better define for farmers what are desirable parent plant populations. Carter (in Wolfe, 1982) suggests a need for 200 to 700 medic plants/m^2 with a soil seed reserve of 200 + kg/ha at the start of autumn for good medic pastures. Wolfe (1982) argues that winter productivity of subclover is a function of initial plant density. Murphy will later point out that the ideal lucerne plant densities are 10-15 and 25-40 plants/m^2 for dryland and irrigation respectively.

(ii) Parent plants produce seed which can be held on the plant for varying periods of time. Hence the time of release and subsequent dispersal of seed might vary between species.

(iii) Different types and combinations of dispersal mechanisms may operate; there are sometimes special adaptations which assist this: e.g. sheep carry subclover and medic burr; many legumes with hard seed and some grass seed (e.g. kikuyu) remain viable after passage through the animal. Cattle are best in this regard as dung pats provide more ecological space for germination of the seed. John Miller will describe how spray graze and spray topping have been adopted to stop seed dispersal and the buildup of competition from a new generation of seeds.

(iv) Finally, seed may enter the soil seed bank (i.e. the reserve of viable seed present in the soil and on its surface) through sowing by man to meet particular management objectives. This has been seen to date as the most common form of pasture establishment but it is by no means the only method - nature has been doing it a lot longer and we can learn from this. Greg Lodge and Colin Fitzhardinge will explain how 'new' pastures can be established or maintained through the use of grazing management. Sown seed is considered subsequently.

'Natural' dispersal mechanisms also commonly operate after the pasture has been established. Seed dispersal and the ability for seed to survive in the soil for long periods allows the buildup of soil seed reserves varying significantly in composition from the existing vegetation. Thus parent plants may be separated in time and space from the existing soil seed bank. White clover has proportionally more seed in the seed bank than there are plants in the pasture; seed densities are usually 200-300/m^2 but may reach 15000/m^2 (Burdon, 1983).

Seed entering the soil seed bank may be in one of four dormancy states (i.e. in dormancy the seed is alive and although external conditions are favourable it is unable to germinate) or non-dormant (Roberts, 1981). Hardseededness in the legumes will be the dormancy category which is most familiar - the seed coat is impermeable to the entry of water. Other categories are discussed by Murray (1984).

The dormancy status of seed may change as it enters the seed bank, or in the seed bank and the study of the dynamics of movement from 'hard' to 'soft' pools (figure 1) has been the focus of recent research. The key point to emphasise is that this is a dynamic system.

Dormancy mechanisms are of considerable adaptive significance; in mediterranean climates, legume hardseededness and grass seed dormancy enable these species to escape summer temperature extremes and drought. New varieties of subclover have increased hardseededness which is judged to enhance their potential ecological success in our farming systems. This has four major practical implications:-

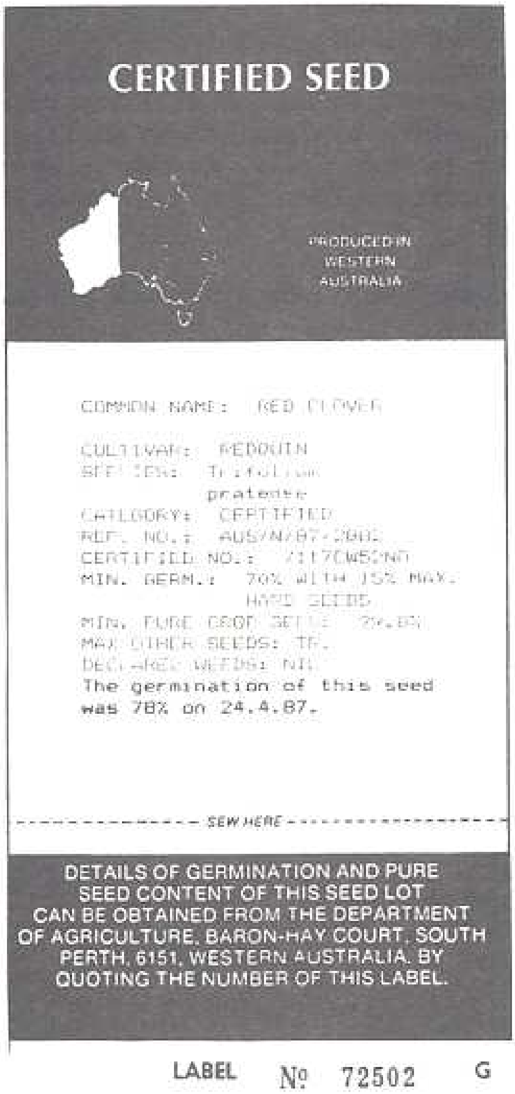
(i) Choice of cultivar or species based on dormancy characteristics e.g. the hard seeded cultivar Junee versus the softer seeded Woogenellup subclover.

(ii) Spread of risk by sowing a percentage of hard seed; farmers as consumers should exploit to advantage new labelling requirements on bags of pasture legume seeds to ensure that seed with the required hard seed percentage is purchased (figure 2). Alternatively farmers may request seed merchants to modify their scarifying procedures to provide a seed lot with the desired proportion of hard seed.

(iii) The need to know something of the seed biology, including dormancy of the species in your pasture. This is necessary to manipulate grazing management, defoliation and for soil disturbance to ensure either seed enters or does not enter the seed bank or alternatively that germination and establishment of seed of desirable species already in the seed bank occurs.

(iv) There is a need to better know how to manage or manipulate soil seed banks to advantage. A corollary of this is the need for simple and reliable measurement procedures. Indispensible is the need for managers to observe what is happening in their pasture and to know what it is they are seeing or perhaps not seeing.

FIGURE 2. Information available to consumers on the label of a bag of certified seed.



SOWN SEED

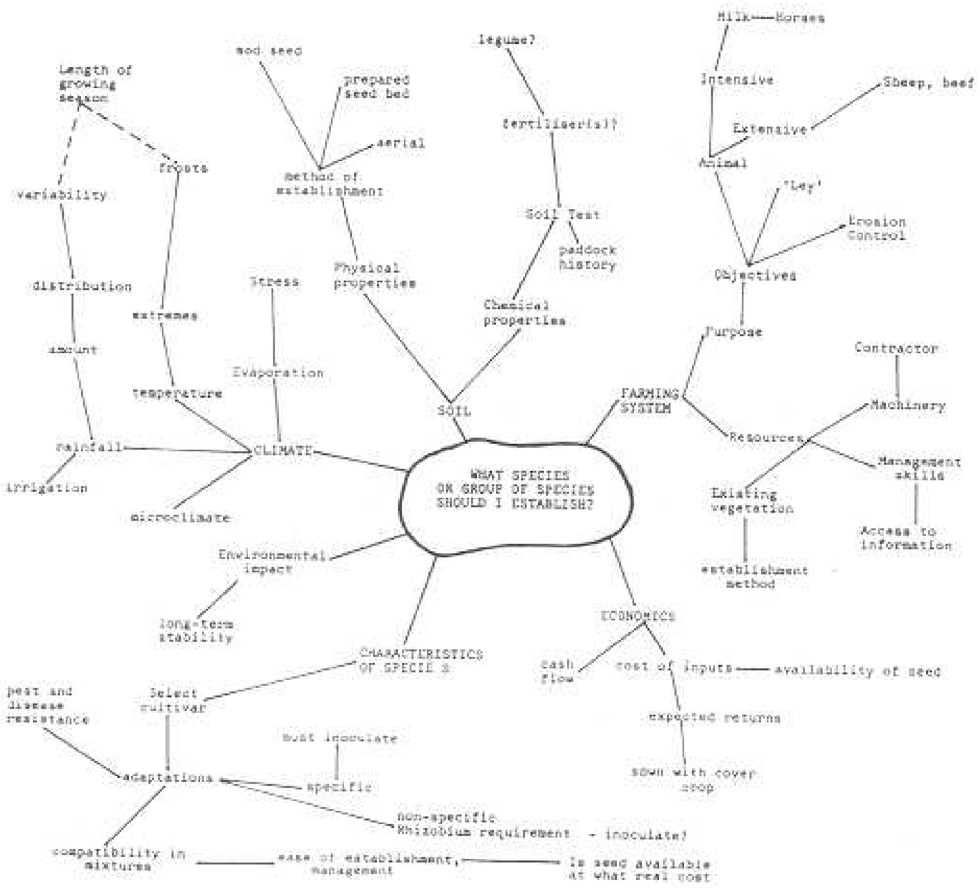
Success in sowing is related to the extent to which competition from existing vegetation and potential vegetation (from seed already in the soil seed bank) is reduced so as to create biological space that can be exploited by sown seed of known quality.

Most pasture seed is sown at a rate of 100-170 seeds per m², however natural seed loads in the soil commonly range from 5000 to 50,000 seeds per m². Sown seed must therefore compete for microsites where they are capable of germinating. These microsites must provide all that is needed for germination (correct temperature, water, sometimes light and oxygen), leaf expansion (temperature, light, vapour pressure deficit and exposure) and root penetration (the right soil particle size, pore distribution, aeration, pH, mineral element availability and soil moisture content). Cregan (1987) and speakers to follow cover the practical aspects in more detail. It is worth noting Silcock's (1980) observation that much of the establishment technology we have developed in Australia has attempted to adapt the sowing environment rather than selecting varieties which are easy to establish. A further aspect is the failure of many germplasm evaluation programs to evaluate under establishment conditions commonly used on farms: e.g. sod sowing; aerial sowing; undersowing; low sowing rates; use in mixtures etc.

The decision to sow should not be made overnight; a period of appropriate management ranging from weeks to months will be required for the paddock in question. The decision making process can be envisaged as a type of decision tree; once one decision is made (e.g. to sow a particular paddock) another series of options present themselves (e.g. what species or cultivars to sow). The critical steps are:

(i) Pre-sowing management of the paddock - e.g. grazing management (stocking rate), possibly fire and herbicides or fodder conservation.

Figure 3. Factors involved in selecting species



(ii) Species and cultivar selection; this is an extremely important decision which must be made by managers who know their own property and the factors involved in making a decision about species choice (figure 3). This is not the sort of decision that can be left to your seed merchant, local agricultural supplier or wool firm, even if they are your only source of credit. Cost of seed is a poor criterion on which to base your choice of species or cultivar as is shown in table 2. This is one of the few inputs which has declined in price in real terms in recent years.

TABLE 2. Yields and returns for five ryegrasses in trials at Taree and Gloucester.

RYEGRASS	AVERAGE YIELD OF D/MATTER	MILK PROD.	VALUE OF MILK	OTHER FARM COSTS	SEED COSTS	NETT RETURN
	kg/ha	l/ha	$/ha	$/ha	$/ha	$/ha
Tetila	8,650	6,750	1,769	1,070	22	677
Barcoo	9,450	7,352	1,932	1,169	34	729
Richmond	9,500	7,391	1,942	1,175	40	727
Concord	9,700	7,547	1,983	1,200	56	727
Midmar	10,350	8,052	2,116	1,280	62	774

Source: Launders (1987).

(iii) Purchase of good quality seed of known varietal purity, germination, free of weed and other crop contaminants and, with legumes, of known maximum hard-seed percentage (figure 2).

The principle of sowing is to give the sown species the greatest competitive advantage. Later you will hear from speakers in this program with many years experience in managing aerial sowing and sod-seeding where control of competition is critical. If there are no competing plants or seeds, then the time, and method of sowing simply optimise the time, rate and depth of sowing; the arrangement of the plants and the structure of the soil (through cultivation and seedling nutrition including seed treatment). The management implications of the three main methods of sowing are summarised in table 3.

SEEDLING EMERGENCE

The processes of germination end with the protrusion of the radicle or root tip from the seed coat. Emergence is best defined as being completed with the penetration of the shoot above the surface of the soil - it is thus largely a property of the growing medium of the seed. Speed and effectiveness (or success) of emergence depend on seedling or emergence type, seed size and genotype, soil type, the environment and seed depth. Soil obstruction may be the greatest single cause of pasture seedling mortality before establishment (e.g. Leslie, 1965). This is a poorly researched area. Arndt (1965) showed that, as the soil surface is wet, drains and then dries, its upward impedence (i.e. the resistance it would offer to a seedling attempting to break through the surface) increased two to three fold during wetting and up to nine-fold relative to dry soil, as that soil was dried from field capacity to a 6 per cent water content.

Many farmers are aware of this and have adapted their sowing technology to help cope with soil crusting; I am aware of one successful farmer on irrigated country near Forbes who has a seed box behind a fluted Cambridge roller followed by light covering harrows. In this way moisture is brought to the surface but compaction is minimal above the sown seed; natural rainfall is relied upon and irrigation is not used for pasture establishment.

I am sure there are many examples such as this of important innovations made by farmers to aid establishment. I am not convinced however that farmers and researchers effectively share these ideas and I trust this Conference will enable us to do so.

TABLE 3. Management implications of the three main methods of sowing.

Characteristic	Surface sowing (No soil disturbance)	Sod seeding or Direct drilling (One pass with minimum soil disturbance)	Sowing in prepared seed bed (Variable number of cultivations)
Risk of erosion	Low	Minimal	High
Fuel usage	Low	Low	High
Labour costs	Low	Medium	High
Implements used	Few, e.g. by hand or spreader, or specialist, e.g. aircraft.	Tractor and sower	Variable number: ploughs, cultivators, harrows, sower.
Surface trash	Not removed; minimised by grazing, burning or perhaps herbicides.	Removed by grazing and reduced by herbicides	Incorporated
Root competition	High	High, reduced by use of herbicide.	Low
Light competition	Variable, depending on management.	Variable, depending on management.	Low with good weed control.
Insect/pest control	Poor; may need pesticide.	Poor; may need pesticide.	Best
Sowing depth	No control surface only	Control depends on machinery, soil moisture and surface trash.	Good control
Time to grazing	Up to 2 years	Grazing in year of sowing.	Grazing in year of sowing.
Soil structural problems	No effect	Minimal; enhances structure in long term.	Can be created; can use machinery to break subsoil compaction.
Soil moisture	Critical	Critical; conserved under killed sward.	Not as critical.
Soil temperature	Seed exposed to extremes	Soil temperatures may be reduced. Late sowing can be a problem.	Depends on soil type and depth of sowing.
Fertiliser placement	On surface, poor control	Can place below or beside seed; good control possible.	Can place below or beside seed; good control possible.
Opportunity cost	Variable	Low; can graze to sowing.	High

Source: Pearson & Ison, 1987

ESTABLISHMENT

A definition of establishment is difficult; the term really attempts to estimate the success of new seedlings in gaining "ecological space" - a share of the light, water and minerals which have to be divided among individuals in the whole pasture.

With annual species, establishment cannot be assured until the new generation of parent plants have flowered and set seed. In this way plant establishment can be distinguished from the establishment of the pasture as a whole - pasture establishment and regeneration are all-embracing terms to cover agronomic practices related to sowing and seedling development from the time seed takes up water (imbibition) to a point where the seedlings have a high probability of survival, i.e. the sown seedling population has stabilised. As Harper (1977) put it: the chance of a seedling surviving and being productive is greatest if it, a) established before its neighbours enabling it to preempt resources; b) is well separated from its neighbours and c) has weak neighbours......sounds like the way farmers behave with each other!!

SUCCESS

At our conference last year Frank Crofts (Crofts, 1986) provided a thoughtful overview of the strategies available to farmers in the continuing cost-price squeeze. Success for the individual in terms of pasture establishment or renovation will depend on the strategy or combination of strategies adopted. Mick Townsend will address the issue of making pasture establishment pay and will consider the main analytical methods used to determine profitability. Given the scenario I outlined in my introduction, economic success in the long term is going to involve compromises between looking for productivity, stability and sustainability of our pasture resources.

I hope that by now I have opened up a Pandora's box for that has been my intention. More cost-effective establishment and regeneration of pastures is, in my opinion, an area of critical importance to members of this Society, yet an area where significant gains can be made by application of existing technology. New technologies in the areas of machinery development, nutrient, pesticide and herbicide treatment of seed (Campbell), more cost effective use of herbicides; better species and cultivars and possibly manipulation of seed banks also hold promise. This promise will not be realised however if we do not understand something about all the variables in the pasture establishment or regeneration equation and if through our management of these we are unable to sustain or increase animal production or the value of our land resource. I realise I have not provided you with many answers, but that is for the speakers to follow, after all there can be no answers until we know what questions to ask.

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