WHOLE FARM MANAGEMENT OF DEER

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Abstract

Whole farm management of deer involves a complex interaction of human, animal and environmental factors. However, simple universally applicable principles apply. This paper discusses those principles using red deer production under pastoral systems, based largely on New Zealand experience, as an example. The first imperative for good management is development of a clear goal, and a broad strategy for its achievement. Knowledge of the attainable range of outcomes for production, reproduction, growth and health of deer and their biological limits can then be applied to the selection of individual production objectives, tailor-made for each producer.

Research, both from institutions and commercial farms, has developed new technologies that can be applied by producers to realise their chosen production and profitability targets. Group extension projects have been successful in advancing whole herd management on participating farms. There is significant gain to be made on most farms by employment of professional expertise.

A systematic approach to production target setting is a pre-requisite to evaluation of risk factors that may either positively or negatively influence each target. An effective method of designing management systems to achieve targets is to undertake a risk evaluation for each target, followed by development and implementation of a sound risk management plan for each. This approach to whole herd management will enhance the stability and security of deer herd production, and improve sustainability and satisfaction for the individual producer into the future. Data from commercial deer farms in New Zealand shows that improvements in productivity through improved knowledge and understanding can yield increased profit approaching as much as 50%.

Introduction

The range of deer production systems worldwide has been described in previous World Deer Farming Congress proceedings (Woodhouse, 1993; Elliot, 1998), and is updated elsewhere in these proceedings. Two common themes are evident in deer industries globally: adoption of the dramatic increase in knowledge and understanding of deer and deer production; and the evolution from generalist to specialist production systems. Assimilation of new knowledge of deer and deer production is daunting, not only to producers, but to all involved. Science-based initiatives focusing on production and products are being adopted and verified by leading deer producers. In turn, group extension projects such as those described by Campbell (1998) and Walker *et al.* (1999a) provide a focus for the adoption of new technologies by the broader deer producer population by demonstrating their practical relevance and success. In this way, the expertise of deer farm managers is constantly improving.

Domestication of deer after thousands of years of evolution has occurred only in the past few decades (Fletcher, 1998). Selection for traits favouring domestication will have had very little impact over that short time. This provides a unique opportunity to recognise the inherent characteristics of these newly domesticated species. This should be a pre-requisite to designing and implementing management systems that achieve the optimum deer and economic result (Chardonnet, 1991). Deer production is generally best in environments that most closely mimic their natural habitat, and in systems that provide for their individual preferences.

Most deer producers want to derive the optimum from their deer. To achieve this they must provide the optimum for their deer. This paper will examine some of the principles of whole farm management aimed at achieving the optimum for both producers and deer, based on modern technical knowledge of the biology of deer and deer production systems. It will propose an holistic approach to the evaluation of key factors associated with optimum deer herd health, production, reproduction, wellbeing and financial outcomes. While this presentation largely employs the New Zealand red deer pastoral farming system as a model, the principles discussed can be applied to the full range of deer production systems internationally.

The "Whole Farm" Or "Multi-Factorial" Philosophy

The holistic or whole farm approach to deer herd management is chosen based on the concept that most, if not all events, decisions and outcomes on a deer farm are interrelated. This is known as a "web of causation". This is a concept frequently applied to the investigation and understanding of animal diseases (Thrusfield, 1995) and is readily applicable to deer herd management. It is based on the following premises:

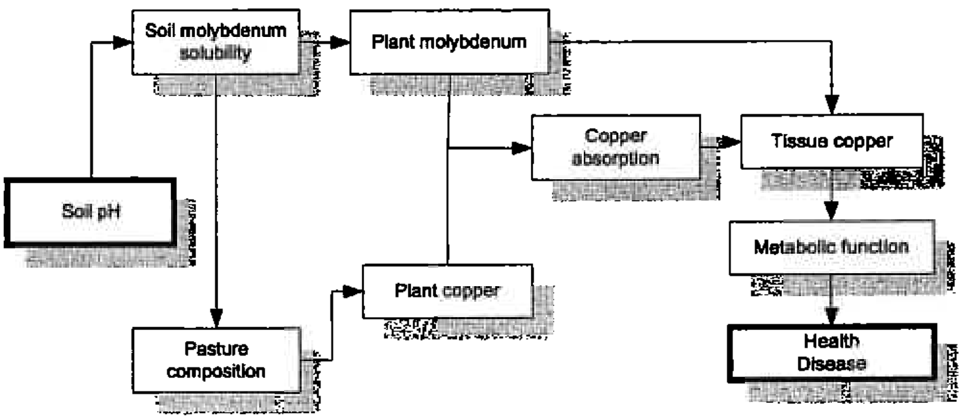
- Outcomes are rarely related to single causative factors;
- Changing one factor usually has an effect, either positively or negatively, on a multitude of others

Factors can affect outcomes either directly, or indirectly, through their influence on other factors that in turn influence the outcome.

Webs of causation acknowledge the complexity of systems. They have been applied by Audigé (1995) to enhance our understanding of commercial deer production systems and as a tool for developing a better understanding of management factors that contribute to health, growth, reproduction and antler production on New Zealand deer farms. Simplified examples of such models are given in Figures 1 and 2 to demonstrate the principles involved.

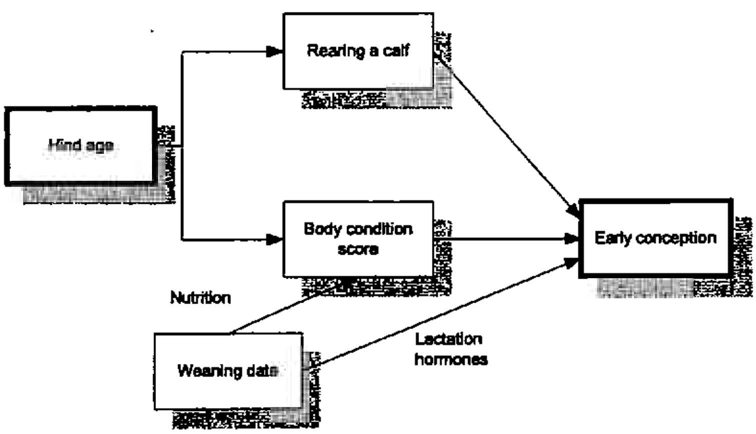
The outcome in Figure 1 is optimum health and production through maintaining tissue copper concentrations. Soil acidity (pH) directly influences pasture composition and therefore sward mineral and other element content, including molybdenum. Indirectly, animal tissue copper concentrations may be affected because plant molybdenum concentration directly affects both tissue metabolism of copper in the animal, and availability of copper before it is absorbed through the intestinal lining, by formation of insoluble chemical complexes, thiomolybdates, in the stomach. Changing soil sulphur would have a similar effect. In reality there are a number of other factors which will also affect tissue copper concentrations, and therefore metabolic function, which are not necessarily directly related to dietary copper per se. However, this model shows that changes in soil factors aimed at improving pasture production, if done in isolation without knowledge of the direct and indirect effects of those changes, (for example on animal copper status), the net effect could be better pasture production for poorer performing animals.

Figure 1. Simplified multifactorial model for decision making. This diagram explains direct and indirect influences that changing soil pH could exert on deer copper concentration, and subsequent effects on metabolic activity and health.



The second model (Figure 2) presents a small section of larger models developed by Audigé *et al.* (1999a) for reproductive outcomes in adult hinds.

Figure 2. Simplified multifactorial model for decision making explaining direct and indirect effects of age of hind on conception rate early in thebreeding season, and interactions with body condition score (source Audigé *et al.*, 1999).



In this example, body condition score is a key determinant of early conception in hinds. This is influenced by hind age, whether or not the hind reared a calf in the previous breeding season, and the weaning date, influencing the nutrient demand placed on the hind. Lactation hormones directly suppress or delay onset of oestrus. Therefore, weaning date has an indirect effect on conception rate and date through influencing body condition score at the same time as having a direct effect on conception rate and date through influencing the hormonal status of the hind. Pollard et al (2000) recently described a 12-day delay in mean conception date in post-rut weaned hinds compared with those weaned before the rut. This was associated with a mean reduction of 0.5 of a body condition score on the late weaned hinds.

In addition to effects on the hind, post-rut weaning resulted in a higher live weight and weight gain in calves weaned late. Thus, at least in the short term, if the objective was heavier calves, late weaning would be chosen. If, on the other hand, early conception was the objective, early weaning would be chosen. A further complication of this model however, is that the hinds that conceived late this year because of late weaning, would have calves born the later following year. Those calves would therefore be lighter than their earlier born counterparts, so it is likely that the effect would be cancelled more than one year later. This demonstrates that the long-term effect of management decisions should be thought through before their adoption.

Thus, the best farm management decisions are made when all of the issues, contributing factors and implications of that decision are known. While in absolute terms that ideal may never be achieved, accessing and utilising current knowledge should achieve a high proportion of "best" decisions.

EXPERIENCE, KNOWLEDGE AND EXPERTISE

Knowledge, experience and achievement

Most people learn best by doing (Dryden and Voss, 1993). Thus, experience is a significant determinant of one's ability to make the right management decisions. Experience alone, however, may not be sufficient to achieve all the desired outcomes since experience alone may not encompass best or optimum practice. Seeing, reading and hearing are also essential components of the learning process. Deer farmers worldwide have demonstrated a significant ability in this regard in seeking and adopting new ideas and new technologies, and there has been a demonstrable improvement in deer farming efficiency during the industry's short history. However, further potential exists for most, as will be demonstrated below.

Only a small proportion of farmers have achieved the currently defined limits of productivity (Audige, 1995). Those who do, challenge the limits and provide the questions for research and development. Indeed, many of those farmers themselves advance knowledge through their own innovation in developing solutions to problems and answers to questions.

The rapidly growing pool of technical and general knowledge of deer production worldwide ranges from molecular genetics through agronomy, nutrition, production, health, disease prevention, welfare, reproduction, handling facilities, breeding etc. Thus, for most outcomes knowledge exists to achieve the optimum management practices within currently defined biological limits. Those limits will be pushed further as new knowledge evolves.

Access to knowledge

Access to and application of knowledge is one of the significant pathways to improvement of production and profitability. All sources of knowledge are available to farmers. Some are free. However, deer producers are generally reluctant to seek and pay for professional expertise, which can accelerate the up-skilling process. Thus, in practice there is still a significant gulf between existing knowledge and its application across the deer industry. This is, in the authors' opinion, one of the significant impediments to improved management of deer farms globally. There have been numerous examples from other industries in many countries where the cost benefit of employment of professional advice has yielded enormous economic returns. These are generally available at minimal capital cost. Most major gains have been through developing a better understanding and knowledge base of production systems, ie. education. The expression...*The cost of education may appear high, but the cost of ignorance is higher* ... is very relevant to deer production systems.

While individual farmers working with their professional advisors is probably the most effective method of improving deer herd productivity, there have been a number of successful extension projects based on group dynamics. Two examples of note from which data is discussed below are the "Deer Master" project in Canterbury and the Richmond Wrightson Deer Performance (RWDPP) projects in Hawkes Bay, New Zealand (Campbell, 1998; Walker *et al.*, 1999a). These projects acknowledge that enhanced understanding of deer production systems can be achieved by learning collectively from academics, researchers, advisers, other farmers and other industry sectors. They involved groups of ten to sixteen farmers who have a common objective of improving their production and profitability. They meet regularly with specialist agricultural and veterinary advisors, researchers and academics on each others farms. They record inputs and outcomes, discuss and debate ideas and adopt new technologies to improve their farming efficiency and profitability. Data is managed centrally by the advisors, and is processed to be available to all participants. In turn, those projects provide focus and inspiration to others through seminars, field days and contributing to conferences open to all industry personnel, and recently, by publication of a "Deer Industry Manual" (Beatson *et al*, 2001) summarising data and sharing technology.

Effect of expertise on management outcomes

Reproductive outcomes have been chosen here to demonstrate the effect of adoption of the whole farm management approach by these groups. It should be noted, however, that many of the key factors contributing to reproductive success also contribute positively to other production outcomes such as health, growth and velvet production. Audigé (1995) observed that farmers achieving the highest productivity in any one of those outcomes were invariably amongst the highest achievers of the other outcomes.

Data in Tables 1 and 2 show a significant difference in pregnancy rate and conception date between project farms adopting new technology compared with district average farms. These improvements have largely been due to adoption of the management recommendations for improved reproductive performance as discussed by Beatson *et al.* (2000), Wilson *et al.* (2000) and Walker *et al.* (1999b), based on models proposed by Audige *et al.* (1999b). To demonstrate the impact of adoption of optimum management systems for reproductive outcomes, a comparison of two deer herds is provided as shown in Figure 3.

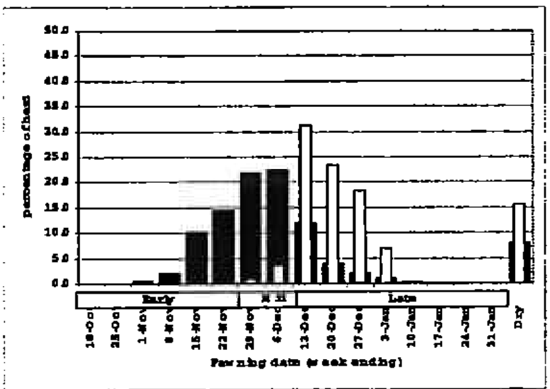
Table 1. Mean pregnancy rates (%) of hinds on extension project farms (n = 12) compared with district average data, demonstrating the impact of adoption of optimum management practices (from Walker *et al.*, 2000 and 2001).

			District average	Project farms
ADULT		Year 1	82	92
		Year 2	91	97
		Year 3	91	96
	Mean		**88 (N=13226)**	**95 (n=7342)**
2-year-old		Year 1	61	81
		Year 2	74	82
		Year 3	72	83
	Mean		**69 (n=8709)**	**82 (n=2628)**

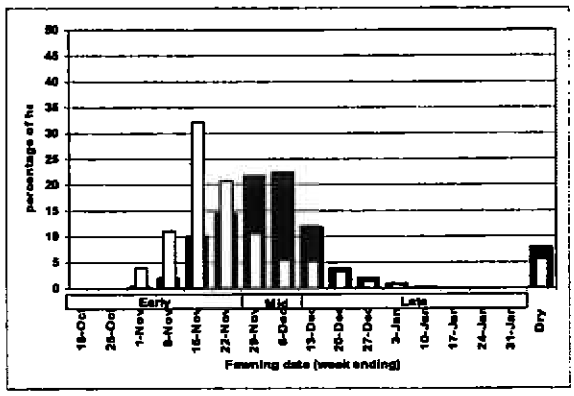
Table 2. Proportion (%) of hinds conceiving early (before April 1) and late (after April 30) in Years 1 and 2 of an extension project demonstrating the impact of adoption of optimum management practices in the second year on group average performance (Walker *et al.*, 2000)

		Year 1	Year 2
CONCEIVING EARLY			
	Adult	13	57
	2-y.o.	0.3	7.4
CONCEIVING LATE			
	Adult	9	4
	2-y.o.	42	14

Figure 3. Predicted calving dates based on pregnancy profiling from two farms for the 1997 and 1998 years. The averages of all farms studied (n=16 over 2 years) are in black bars and the individual farms chosen for comparison are in open bars (from the Deer Master project, Wilson *et al.*, 2000).



Farm 1: Late conception and low pregnancy rate



Farm 2: Early conception and high pregnancy rate

These figures compare a deer herd with a late median conception date with one that has an early median conception date. The black bars show the average conception pattern across all 16 herds in the project over 2 years, combined. Concurrently, the late conceiving herd had a significantly lower conception rate. This is because factors that contribute to early conception also contributed to conception rate per se. The key factors contributing to the difference are presented in the section on reproductive objectives below.

A partial budget comparing those two herds is presented in Table 3 (from Wilson *et al.* (2000). This analysis shows a 48% increase in return for Herd 2 with a better reproductive performance.

Table 3. Performance data and financial return for Herds 1 and 2 (Figure 3) based on standard production and year 2000 price assumptions.

	Herd 1	*Herd 2*
Pregnancy rate %	84	96
No. pregnant	271	310
Mean calving date	Dec 20	Nov 20
No. weaned	249	285
Ave. wt. Mar 1 (kg)	30.3	39.3
Ave. value ($)	121	157
Total value ($)	30 179	44 745
Difference		**$14 566 (+ 48%)**

Further examples of the effectiveness of adoption of current knowledge are shown by a 14.5 percentage point improvement in pregnancy rate of rising 2-year-old hinds using a spiker mating regime (Walker *et al.* 2001), as proposed by Audigé *et al.* (1999b), and a 13 percentage point increase in conception rate of red deer mated with terminal sires. The latter employed an experimental approach based on theories developed by project members to solve the problem of apparent lowered conception rates to Wapiti terminal sire stags (Walker *et al.* (2001).

ACHIEVING THE DESIRED OUTCOME

Deer herd management should be about self-determination. The best outcomes are most likely to be achieved if there is motivation underpinned by sound planning, an understanding of direction, and adoption of relevant technologies. The following section is based on two principles: firstly, that the outcome must be defined ("if you don't know where you are going, you seldom get there"); and secondly, the outcome must be measurable ("if you can measure it, you can manage it"). Wilson and Audigé (1996) described these principles in terms of deer production systems.

Goal

A goal, in effect, is the producer's ambition. This provides the broad motivating pattern for the farm and encompasses such issues as lifestyle, financial, environmental and esoteric considerations. It reflects the nature of the person, combined with the financial and physical environment. It is essential that the goal is committed to writing.

An example could read:

- To develop a profitable deer farming enterprise of repute;
- To enhance the capital value of the station for future diversified potential;
- To conserve and exploit the aesthetic environmental qualities of the property.

Aim

This describes the route chosen to achieve the above goal, taking into account personal preferences. Aims begin to focus on the animal enterprise, eg. breeding, finishing, velvet, or mixed, and what the desired revenue streams may be. An example could be:

- Developing an elite breeding herd of red deer hinds with sale of weaners as the primary revenue source

While at the same time:

- Minimising labour requirements.

Objectives

Objectives fall into general and specific categories.

General objectives

General objectives may be to:

- Expand the breeding operation;
- Produce weaners for sale in autumn;
- To produce deer carcasses to market specification at the time to achieve best market price
- To develop relationships with buyers to establish the desired product;
- To develop the property by increasing the deer fenced area and improve pasture quality and quantity through agronomic, soil and management strategies.

General objectives will help define the management strategy as a prelude to determining individual production objectives. For example, in a breeding and weaner sale scenario, the most profitable outcome may be achieved by:

- Maximising the number of progeny available for sale as weaners by:
  - › optimum conception rate
  - › optimum foetal and calf survival to weaning
- Maximising the weight of progeny through:
  - › achieving the earliest possible conception date
  - › optimising nutrition through lactation and immediately post-weaning
  - › optimising genetic potential for growth by breeding and selection
- Maintaining optimum health status of the herd to reduce clinical and sub-clinical losses.

Specific objectives

Setting specific individual objectives or targets should be in relation to the farmer's overall farming goals, aims, ability, the physical and financial environment, and motivation. Targets can be chosen to achieve the desired performance level. These may be to set realistic and achievable objectives for incremental improvement, or to achieve targets for the ultimate performance potential of the biological and management system (Wilson and Audigé, 1996). Implicit in the concept of target setting and monitoring is the ability to accurately define and measure the desired outcome.

Defining production outcomes

A significant body of literature exists which defines the range of outcomes currently achieved on commercial deer farms in New Zealand (Audigé, 1995; Wilson *et al.*, 2001a,b). A modest amount of data is available for Wapiti (Haigh and Hudson, 1993). This section will briefly discuss the data available for, and the principles associated with, defining management systems that can be employed to achieve the specific objectives chosen for a given farm. It will also present recent research data for growth, showing that adoption of research findings can extend production levels significantly beyond that currently achieved by even the best producers.

Reproduction

The range of reproductive outcomes from four surveys of New Zealand deer farms is summarised in Table 4 (Wilson *et al.* 2001a). Limited data for Wapiti in Canada have also been published (Friedel and Hudson, 1994).

Table 4. Published survey results for ultrasound scanning pregnancy rates for rising 2-year-old and adult farmed red deer in New Zealand (From: Wilson *et al.* 2001a).

			Rising 2year-old				Adult		
Study	Year	No. farms	Total no. scanned	Mean herd preg %	Range between herds %	No. farms	Total no. scanned	Mean herd preg %	Range between herds %
Audigé *et al* 1999									
	1	14	378	83.6	50-100	15	1783	96.9	92.7-98.8
	2	14	413	85.8	50-100	14	1683	96.8	84.6-99.5
Lawrence & Linney 1998									
	1	14	NS	76.7	33-98	14	NS	93.0	89-99
Beatson* *et al 1999*									
	1	14	1136	82.9	56.5-100	14	4638	89.3	72.7-100
	2	11	1146	85.2	80-100	9	3681	91.6	78.3-98.3
	3	11	1614	77.8	51.9-95.9	12	4480	94.8	88.6-97.9
Walker *et al*, 1999b									
	1	11	616	81.2	38-100	12	2180	92.3	78-98
Overall+		42[x]	5303	81.8	33-100	41+	18445	92.9	72.7-100

NS = not stated

Wilson *et al.* (2001a) also present the range of pregnancy profiles (see figure 3 for examples). Those data show that significant improvements in reproductive performance are possible on most deer farms. There have been a number of investigations into methods of improving reproductive performance. The first step in that pathway is defined by a combination of conception rate and date. (Audigé, 1995; Audigé *et al.*, 1999a,b and 2000).

Among the key factors contributing to early conception date and high conception rate, are:

- Hind body condition score: A minimum score of 2.5 must be achieved (see Audigé *et al* (1998) for the method for body condition scoring of deer)
- Weaning date: Pre-rut weaning, preferably at least 2-3 weeks before onset of first oestrus
- Selection of hinds successfully rearing a calf: Hinds rearing a calf are about 3 times more likely to conceive and rear a calf again.
- Early joining date: This achieves a "stag effect" inducing the hind into oestrus earlier. The stag should be introduced at least 3 weeks before onset of first oestrus
- Experienced sires give, on average, a higher conception rate
- Back-up sires provide an insurance for infertile or sub-fertile primary stags
- Avoidance of disturbance

For yearling hinds, research and practical experience has now shown that the best conception rates are achieved by mating with multiple spiker stags, in addition to the factors above.

While this example is for conception, a further set of criteria for achieving optimum weaning percentage has been developed (Audigé *et al.*, 2000).

Growth and venison production

The range of bodyweights and growth rates observed on deer farms using a mixed sward of perennial ryegrass/white clover (usually 80:20) (Beatson *et al.*, 2001; Wilson *et al.*, 2001b), provide the farmer with the opportunity to select the target weights appropriate to their production system. Summary data from Wilson *et al.* (2001b) is presented in Tables 5 and 6. While growth rates are a measure of venison production, a further measure is the proportion of animals achieving the desired target weight at the optimum time for slaughter, and to achieve the optimum biological efficiency of venison production. Wilson *et al.* (2001b) reported an average of 8.7-14.1% of rising 1-year-old stags on survey farms achieved the target of 50 kg carcass weight by 12 months of age. The highest performing farm achieved 48%.

Table 5. Overall mean, and range of farm mean body weights (kg), for weaner (4-month) and 1-year-old red deer from commercial farms (n = 16 farms, 2 years observation) (From: Wilson *et al.*, 2001b).

			Individual means		
Age*	**Sex**	**Overall mean**	**Minimum**	**Maximum**	**Difference (%)**
4-month (April 1)	M	49.8	43.0	55.5	+ 29%
	F	46.4	30.3	54.4	+ 42%
12-months (Dec 1)	M	81.2	66.7	102.9	+ 54%
	F	71.2	59.4	88.9	+ 49%

* Data was standardised to given dates by extrapolation using daily growth rates.
M = Male
F = Female
Source: Wilson and Audigé (1996)

There has been a significant amount of research into alternative production systems to achieve significantly higher growth rates and up to 100% of animals achieving optimum slaughter weights by one year of age (Barry *et al.* 1998a,b). These data, summarised in figures 7 and 8, demonstrate that forage species influences the ability of the animal to achieve its biological potential for growth. A number of factors including palatability, quality and digestibility, described by those authors, contributed to those differences. Thus grazing deer on conventional pastures limits their ability to achieve their genetic potential. Further technological understanding of deer production may advance even these new limits in the future, as research strives to develop systems that best meet the requirements of the animal.

Table 6. Overall mean (± SD) growth rates (g/day) for red deer grazing PRG/WC swards during the first year of life (From Wilson *et al.* 2001b).

			Season	
Study	**Sex**	**Autumn**	**Winter**	**Spring**
Moore *et al*, 1988*	M	103 ± 48	72 ± 41	242 ± 13
Research Farm	F	95 ± 50	41 ± 19	163 ± 13
8 years				
Audigé (1995)	M	118 ± 40.5	95.9 ± 42.8	205.6 ± 40.3
Commercial Farm	F	100.2 ± 38.6	54.9 ± 32.2	141 ± 27.5
24 farm years				

Table 7. Growth (g/day) of deer calves during the latter half of lactation (January and February) on various forage species. Values in brackets are relative to grazing perennial ryegrass/white clover pasture as 100, and are thus a measure of relative feeding value (From: Barry *et al.*, 1998a,b).

Study	Perennial ryegrass/ white clover pasture	Red clover	Chicory	*Lotus corniculatus*
	333	433 (130)		
1	331	410 (124)	385 (116)	
2	351		404 (116)	
3	399			485 (122)

[1] Calves all red deer

[2] Half of calves were red deer and half were 0.25 elk:0.75 red deer hybrid

Table 8. Mean growth (g/day) of weaner stags in autumn and spring grazing chicory, red clover, lotus and sulla. Values in brackets are related to grazing perennial ryegrass/white clover (PRG/WC) pastures as 100, and are an index of relative feeding values (From: Barry et al, 1998a.b).

Study	PRG/WC	Chicory	Red Clover	Lotus	Sulla
	Autumn				
1	178	246 (138)			
2	152	235 (155)		235 (155)	
3	192		263 (137)		
4	207		237 (114)		
5	224				315 (141)
	Spring				
1	260	255 (98)			
2	285	335 (118)		283 (100)	
3	341		354 (104)		
4	281		346 (123)		
5	**289**				333 (115)

Animal health

Optimum animal health underpins achievement of growth, production and velvet production, and minimising economic and genetic loss through deaths. There have been few comprehensive surveys of mortality and subclinical disease on deer farms. Audigé *et al.* (2001) categorised losses by cause, age and sex. Data of seasonal losses in each class of deer are summarised in in Table 9. A significant proportion of mortalities are preventable. For example, perinatal losses may be reduced by maintaining calf-proof fencing. Beatson *et al.* (2001) and Audigé *et al.* (2001) identified injuries as a significant cause of loss. A range of preventive measures can be implemented (see below section on risk evaluation and management).

Table 9. Mortality rates (per 100 deer - 3 months) on commercial deer farms (Audigé *et al.*, 2001).

	Season				
Class of deer	**Autumn**	**Winter**	**Spring**	**Summer**	**Annual**
3 - 15 month-old	2.41	2.62	0.42	0.14	5.87
Females > 15 months	0.23	0.67	0.58	0.32	1.77
Males > 15 months	0.38	0.83	0.82	0.57	2.60

Velvet antler

To the author's knowledge, data of Audigé (1995) is the only published objective survey data of velvet antler production from commercial deer herds. That data is unlikely to be useful for benchmarking between farms, since a significant change in the population demographics of stags in New Zealand has taken place since that data was collected in the 1990s. A considerably greater selection pressure is now placed upon velvet-producing stags in New Zealand and elsewhere. Furthermore, velvet production is influenced enormously by the genetic merit of the stag. Without a well established breeding programme within the industry, providing sire referencing and breeding values, it is difficult for a farmer to set an individual production target which is based on factors other than selection on phenotypic characteristics. Genetic expression will only be achieved by optimising stag growth, nutrition and health. Thus, individual farm objectives for velvet antler can be established, either on theoretical desired production levels or on the basis of historical data from that individual farm or blood line.

RISK EVALUATION AS A TOOL FOR MANAGEMENT DECISIONS

Having established the desired individual production objectives, each contributory factor needs to be considered for its ability to influence that objective. A systematic approach is to identify all factors that contribute positively to, and/or potentially limit achievement of the individual objective, followed by development of a management plan to cope with factors of importance or relevance to the farm and the farmer. These are termed "*risk factors*", and they contribute either positively or negatively to the objective for consideration. This section summarises the general principles of risk evaluation and management, using animal health as the outcome example. An example of an approach to a specific outcome can be found in relation to decisions on copper supplementation described by Wilson and Audigé (1998).

Identification of risks to deer health

There is an enormous number of risk factors that contribute to good health or disease. The following provides a short list:

- Previous history of disease occurrence;
- Previous history of subclinical production loss;
- Data monitoring, eg. trace element status, production, parasites;
- Knowledge of the range of potential diseases;
- District risks, eg. ticks, tuberculosis;
- Soil type, eg. trace element status;

- Other stock on the farm, eg. leptospirosis, malignant catarrhal fever, Johne's disease, Tb, salmonella;
- Stock on neighbouring properties, eg. malignant catarrhal fever from sheep, leptospirosis from pigs;
- Topography, eg. water runoff from neighbouring properties, eg. risking Johne's disease, leptospirosis;
- Class and age of stock relative to their susceptibility;
- Seasonal climatic risk;
- Fence security from neighbouring stock;
- Purchase policy, open vs. closed herd;
- Nutrition management;
- Crops, eg. nitrate poisoning, iodine deficiency;
- Supplements, eg. grain overload, laminitis.

Once all of the potential disease risks are identified, an individual management plan can then be established for each of those disease risks.

Risk management plan for individual deer health problems

The risk management plan will be relative to the production target. If high productivity targets are set then high animal health inputs will be required (Wilson and Audigé, 1996). Individual factors to consider are:

- Estimated degree of risk;
- Rise aversiveness of the producer;
- Degree of caring philosophy of the producer;
- Value of individual animals;
- Genetic information contained by individual animals;
- Labour and time;
- Handling system;
- Acceptability of chemicals;
- Commitment and motivation;
- Cost of the procedures against the risk;
- Need for data collection and evaluation, eg. trace elements, parasites;
- Managing introduction of stock, eg. health status of herd of origin;
- Farming policy;
- Risk to sales of disease introduction, eg. Tb, Johne's disease, CWD.

These factors can then be synthesised into a management plan. In practice, most farmers are reasonably risk-aversive, but few adopt this systematic approach to identify all major risks. Consequently, few have comprehensive animal health plans. On most deer farms in New Zealand the clinical occurrence of disease is low and can be relatively easily managed and prevented (Audige et al 2001). Indeed, the most significant risk to many farms is the introduction of disease from other farms by introduction of live animals (eg. tuberculosis, parapox virus, *Brucella ovis*, leptospirosis, cervine herpesvirus, Johne's disease, cryptosporidiosis, and ticks in New Zealand, and CWD in North America).

However, sub-clinical diseases are potentially much more limiting to productivity than clinical disease causing overt illness or death. Furthermore, without a detailed knowledge of the potential diseases and their epidemiology, there are a significant number of manageable risks that are often taken in ignorance. This is an example of where the expression... *what you don't know won't hurt you...* is not at all relevant. Risk assessment using professional expertise is a systematic way of identifying what is not known, and risks that otherwise may be overlooked, sometimes with severe consequences.

Conclusion

This paper has discussed a logical and systematic approach to whole herd management of deer. While this paper is modeled largely upon pastoral red deer farming systems, the principles discussed apply to deer farming systems throughout the world. Security and sustainability of deer production systems is underpinned by expertise, which is a combination of knowledge and experience. Significant technological advances made over the past thirty years of deer farming history are available to all deer producers. The range of potential biological outcomes within current farming systems is now well established, and provides the individual with the ability to determine their personal production targets and to achieve them

Formulation of a clear farming goal and strategy allows the systematic development of individual production objectives. Once those production objectives are defined, a risk management approach identifying positive and negative contributory factors is proposed as a logical method for developing management plans that improve the probability of success of achievement of objectives, and reduce the risk of unforeseen problems. Examples of improvement in production which translate to profitability increases of up to 50% have been demonstrated.

Science, coupled with a desire of top producers for continuous improvement, and international trends for improved production efficiency to maintain economic viability, will drive production potential beyond our currently observed limits.

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