BEFORE THE ENVIRONMENT COURT
I MUA I TE KOOTI TAIAO O AOTEAROA

UNDER	the Resource Management Act 1991
IN THE MATTER	of appeals under Clause 14 of the First Schedule of the Act
BETWEEN	**TRANSPOWER NEW ZEALAND LIMITED** (ENV-2018-CHC-26)
	FONTERRA CO-OPERATIVE GROUP (ENV-2018-CHC-27)
	HORTICULTURE NEW ZEALAND (ENV-2018-CHC-28)

(Continued next page)

STATEMENT OF EVIDENCE OF DR ROSS MONAGHAN ON BEHALF OF SOUTHLAND REGIONAL COUNCIL

AGRICULTURAL AND SOIL SCIENCE

11 February 2022

Judicial Officer: Judge Borthwick

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(ENV-2018-CHC-30)

GORE DISTRICT COUNCIL, SOUTHLAND DISTRICT COUNCIL & INVERCARGILL DISTRICT COUNCIL
(ENV-2018-CHC-31)

DAIRYNZ LIMITED
(ENV-2018-CHC-32)

H W RICHARDSON GROUP
(ENV-2018-CHC-33)

BEEF + LAMB NEW ZEALAND
(ENV-2018-CHC-34 & 35)

DIRECTOR-GENERAL OF CONSERVATION
(ENV-2018-CHC-36)

SOUTHLAND FISH AND GAME COUNCIL
(ENV-2018-CHC-37)

MERIDIAN ENERGY LIMITED
(ENV-2018-CHC-38)

ALLIANCE GROUP LIMITED
(ENV-2018-CHC-39)

FEDERATED FARMERS OF NEW ZEALAND
(ENV-2018-CHC-40)

HERITAGE NEW ZEALAND POUHERE TAONGA
(ENV-2018-CHC-41)

STONEY CREEK STATION LIMITED
(ENV-2018-CHC-42)

THE TERRACES LIMITED
(ENV-2018-CHC-43)

CAMPBELL'S BLOCK LIMITED
(ENV-2018-CHC-44)

ROBERT GRANT
(ENV-2018-CHC-45)

SOUTHWOOD EXPORT LIMITED, KODANSHA TREEFARM NEW ZEALAND LIMITED, SOUTHLAND PLANTATION FOREST COMPANY OF NEW ZEALAND
(ENV-2018-CHC-46)

TE RUNANGA O NGAI TAHU, HOKONUI RUNAKA, WAIHOPAI RUNAKA, TE RUNANGA O AWARUA & TE RUNANGA O ORAKA APARIMA
(ENV-2018-CHC-47)

PETER CHARTRES
(ENV-2018-CHC-48)

RAYONIER NEW ZEALAND LIMITED
(ENV-2018-CHC-49)

ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND
(ENV-2018-CHC-50)

Appellants

AND **SOUTHLAND REGIONAL COUNCIL**

Respondent

Summary of evidence

1 The evidence provided below addresses some specific questions relating to the potential impacts that intensive winter grazing activities and sacrifice paddocks, and the renovation or renewal of grasslands on sloping terrain, can have on soil and water quality. These are identified as activities that can potentially have disproportionately large impacts, relative to their areal extent, on soil and water quality outcomes. The underlying principles that influence key risk factors are discussed, focussing particularly on how vegetative cover and soil (drainage features and structural resilience) and landscape (slope and proximity to waterways) attributes influence contaminant losses to water.

2 The role of land management practices for avoiding or minimising these risks is also discussed. Some activities are shown to be inherently risky due to the strong influence that edaphic features such as slope can have on the transport of sediment and P in surface runoff.

3 Management practices that protect soil structural integrity and maintain plant cover are important actions that minimise such risk, although these are unlikely to fully offset the consequences of intensive farming practices on steep terrain. The relatively weak state of knowledge that exists about the environmental impacts of pasture-based wintering approaches and the consequences of renovating pastures on hilly and steep terrain is noted.

Introduction, qualifications and experience

4 My name is Dr Ross Martin Monaghan. I am a research scientist working within the Environmental Science team at AgResearch, based at the Invermay campus near Mosgiel. I have a Bachelor's degree in Agricultural Science (First Class Hons, Lincoln University) and a PhD in Soil Science (The University of Reading). I have 26 years work experience with AgResearch plus the research experience gained during my PhD and post-doctoral studies (3 years for each). My research projects focus on (i) defining the impacts of intensive pastoral agriculture on soil and water quality, and (ii) identifying cost-effective options to reduce these impacts where mitigation is deemed necessary. These findings have been published in more than 80 peer-reviewed science journal papers and 50 AgResearch Client Reports that I have authored.

5 I have been asked by the Southland Regional Council (**Council**) to prepare evidence for these proceedings.

Code of conduct

6 I confirm that I have read the Code of Conduct for expert witnesses as contained in the Environment Court Practice Note 2014. I have complied with the Code of Conduct when preparing my written statement of evidence, and will do so when I give oral evidence.

7 The data, information, facts, and assumptions I have considered in forming my opinions are set out in my evidence. The reasons for the opinions expressed are also set out in my evidence.

8 Other than where I state I am relying on the evidence of another person, my evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope

9 I participated in expert witness conferencing in relation to these proceedings, and signed the resulting Land Management / Farm Systems Joint Witness Statements dated 22 November 2021 and 6 December 2021.

10 I have been asked by the Council to provide evidence in relation to the Joint Witness Statements I am a signatory to, and the following matters which were outstanding following the expert conferences:

(a) the potential risks to soil and water quality of intensive winter forage grazing practices;

(b) consideration of some specific measures that may be needed to control intensive winter grazing when pasture as the main component of winter diets; and

(c) consideration of the potential risks to soil and water quality of replacing and maintaining pasture on land with slopes greater than 20 degrees.

(d) consideration of the potential risks to water quality posed by sacrifice paddocks.

Land Management / Farm Systems expert conferencing and joint witness statements

11 I participated in the Land Management/Farm Systems expert conferencing process held on 22 November 2021 and 6 December 2021. This conferencing answered a number of technical questions that were provided by the Planning experts. A Joint Witness Statement (**JWS**) dated 6 December 2021 was prepared and signed by attendees, including myself. I stand by the outcomes of this JWS.

12 Below I elaborate on some of the reasoning behind why I agree with particular aspects of the JWS. I also discuss some specific questions that have been asked of me.

Potential risks to soil and water quality of intensive winter forage grazing practices

13 I have been specifically asked to comment on the rationale and evidence that would justify establishing a riparian set-back distance of 10 m for intensive winter grazing on land under 10 degrees of slope. The rationale for such vegetated margins can be ascribed to at least two important effects. Firstly, if left un-protected these near-stream areas can act as critical source areas (**CSAs**) of contaminant transport in surface runoff if they are subjected to intensive grazing. This is particularly likely during wet conditions. Grazing of such areas may also increase contaminant transport to waterways through increased streambank erosion. This is well documented in global literature and is due to the loss of root mass and pulverized soil structures that work together to reduce bank cohesion, leading to collapsed cut banks. Secondly, vegetated buffer areas can act as infiltration and/or deposition zones where particulate material in overland flow from upslope locations (or floodwater over-spill) can be captured. Whilst these beneficial aspects of buffer zones are well recognised, specifying an exact minimum set-back width is difficult due to the variable effects that slope and soil drainage parameters can have on buffer effectiveness.

14 It is generally true, however, that the need for wider buffers increases as river size and associated flood inundation area increases. Channelised flow of surface runoff originating from upslope locations may also quickly overwhelm the ability of an edge-of-field buffer to capture particulate material transported in large erosion events. Because of these

confounding effects, I consider there are three management strategies that can guide buffer designs on land used for intensive winter grazing:

(a) Setting a minimum buffer width in near-stream areas that prevents these zones otherwise potentially acting as CSAs due to soil damage incurred if grazed whilst conditions are wet. Based on reviews by Zhang et al. (2010) and others, suggested minimum widths of 5 m in these locations may also remove 60 – 90% of sediment that is entrained in flow passing through these buffers. This removal efficacy was reported to increase to 70 – 100% for buffer widths of 10 m. The predictive equations presented in the review of Zhang et al suggested increasing buffer widths from 10 to 20 m would deliver only small (1 – 2%) improvements in sediment removal, but would increase P removal efficiency from 69 to 97%[1].

(b) Establishing longer (typically narrower) buffers in zones of convergent flow within the paddock, such as gullies and swales, that are recognised as important CSA features where particulate material is transported via surface runoff. This type of CSA buffer management has been shown to be effective for reducing sediment and P transport (Monaghan et al. 2017) without the need for removal of large areas of winter grazing activity. For the study reported by Monaghan et al., protection of a gully CSA measuring 100 m long by 10 m wide (on average) was shown to reduce sediment and P losses in overland flow from a 2-hectare gully catchment by 60 – 70%.

(c) Setting a minimum buffer width in floodplain locations where river or stream over-spill is highly likely. This width would need to increase as stream size increases, ideally to encompass the flood inundation area.

15 I have been specifically asked to comment on the likely impacts of setting the maximum permitted land area per property used for intensive winter grazing as either 10%, 15%, or greater. This issue was briefly addressed in the Farm Systems JWS. In my opinion, a higher permitted

[1] For scenarios of grass-only or mixed grass and tree buffers.

land area per property of intensive winter grazing, such as 15% rather than 10%, would likely lead to the following outcomes:

(a) Much published research has shown that there is inherently a greater (approximately 2- to 5-fold) risk of N loss from grazed winter forage crops compared to losses from grazed pastures (e.g., Smith & Monaghan 2020). Much of this is due to (i) the timing of urinary N returns to soil when crops are grazed and (ii) the relatively long periods thereafter when paddocks remain bare and plant uptake of N is not possible. Assuming similar management scenarios, we would therefore expect a resulting increase in N leaching to water if the proportional area of intensive winter forage crop grazing increased. Some of this increase could however be off-set by implementing management practices that have been shown to reduce N losses. These include the selection of a forage crop such as fodder beet that contains less N than other brassica crop types, such as kale and swedes, with consequently less return of urinary N to soil when such a crop is grazed. Sowing a catch crop after the forage crop has been grazed in winter has also been shown to reduce N leaching. These management strategies may[2] reduce N leaching per hectare by approximately 50% and 30%, respectively.

(b) Increasing the permitted land area per property used for intensive winter grazing is highly likely to increase the proportional area of bare ground and associated areas of heavily trodden soil. As a consequence, and again assuming similar management scenarios and landscape settings, we would therefore expect resulting increases in losses of sediment and P entrained in overland flow. The magnitude of these increases is likely to be in the order of a 5- to 10-fold increase in losses on a per hectare basis (Monaghan et al 2017; Donovan & Monaghan, 2021). Thus, the increase in contaminant loss is significantly greater than the proportional increase in land area. As for N, some of these increases could be off-set by implementing management practices that have been shown to reduce sediment and P losses (discussed below in paragraphs 22 and 37, albeit the effectiveness of these measures

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2 The term “may” is used to denote that the effects of these measures have only been identified relatively recently and are thus still the focus of on-going research studies.

is unlikely to be enough to reduce losses to those expected from an equivalent pasture setting. This recognises that mitigation measures are rarely 100% effective and also that proactively avoiding soil degradation is usually a much more effective strategy than reactive measures to mitigate damage and contaminant transport.

16 Assessing the likely consequences of increasing the proportional area of intensive winter grazing is a reasonably challenging undertaking that requires expert knowledge. To my knowledge, there is no single tool that is currently available and can be used by practitioners to explore the likely magnitudes and directions of changes in N, P and sediment transport for the range of landscape and management settings that are known to be important determinants of loss risk[3]. The Overseer® model is probably the most useful currently-available tool that can guide N loss scenarios, albeit some management effects (such as the fodder beet response noted above) have yet to be adequately incorporated into the model. Assessing and mitigating the risks of sediment and P transport from farmland ideally requires geospatial modelling tools such as the Mitagator and LUCI models that have been developed by Ballance AgriNutrients and Ravensdown respectively, the two major fertiliser companies in NZ. To my knowledge however, the descriptions of intensive wintering grazing practices in these models also requires improvement, albeit this is the focus of on-going model development.

17 My general opinion is that setting the permitted land area per property used for intensive winter grazing at 15% rather than 10% would, as a general rule, likely increase losses of N, P and sediment to water. Some of these increases could be offset through the implementation of mitigation practises, albeit this would be a challenging task in the case of sediment and P losses.

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[3] This situation could probably be remedied to some degree by the development of qualitative risk indices or frameworks that would provide a likely direction of change.

Consideration of some specific measures that may be needed to control intensive winter grazing when pasture is the main component of winter diets

18 There has recently been increasing interest in wintering approaches that do not rely on grazed forage crops as the main dietary source of winter feed. Pasture-based wintering is one such approach that, intuitively, might result in less soil damage due to the greater protective "armouring" effect of perennial pasture plants compared to annual crops. A likely consequence of this would be less transport of sediment and P in surface runoff. Assuming that the pastures are not badly damaged when they are grazed during winter, pasture growth may also recover quickly and N uptake by the growing plant could thus potentially lower the risk of N leaching post-grazing. Although we could expect a pasture-based wintering approach to be better-suited to well-drained soil types, we unfortunately have little research evidence that supports and quantifies these benefits. A number of research projects are currently underway to test these hypotheses, however. It is also important to recognise that whilst a shift to wintering on well-drained soils will likely reduce sediment and P loss risk, it will conversely increase the risk of N loss to water.

19 Some risk factors associated with pasture-based wintering include consideration of the feasibility of carrying stock on winter pastures, particularly in locations where heavier stock classes are over-wintered on poorly drained soil types. In these situations there is a risk that soils and pastures could be badly damaged due to the effects of animal treading; badly damaged pastoral soils may yield similar amounts of sediment, P and N to those expected from grazed winter forage crop areas. Another important consideration is the potentially confounding effect of a likely increase in winter-grazed areas if shifting from a crop- to a pasture-based approach. Such an increase is to be expected given (i) stock will have a fixed requirement for winter feed provision, and (ii) forage crops will usually provide at least twice the amount of feed dry matter (**DM**) per unit area than pasture e.g. a kale crop can typically have 10 - 15 tonnes DM available per hectare for eating in mid-winter, whereas a pasture that has been closed in summer for winter grazing may perhaps have up to 5 tonnes DM available per hectare for eating in mid-winter.

20 I have no specific and quantitative knowledge regarding the prevalence of pasture-based wintering approaches in Southland. I would expect that this activity is more commonly used for lighter classes of livestock (sheep) and in locations where soil drainage is rapid and treading damage is thus less likely. I have seen the approach successfully used on 2 dairy farms in Southland and 2 in Otago.[4]

21 Adverse effects of this activity could include the potential to badly damage soils and pastures, albeit this would depend on grazing intensity, soil drainage properties, soil structural resilience and the amount of rainfall received. Such damaged areas would need to be re-sown in the following spring, thus incurring additional cost. As noted in paragraph 19 above, these damaged areas may yield similar amounts of sediment, P and N to those expected from areas used for winter forage crop grazing. Due to the greater protective “armouring“ effect of pasture plants compared to that provided by winter forage crops, we might expect that the degree and areal extent of soil damage would be less than that anticipated for areas that have been used for winter forage crop grazing. This armouring effect could however be short-lived if large amounts of supplemental feed have been imported to enable high grazing intensities[5] to be achieved. In any case, the adverse effects should be considered relative to the farm’s current practices and any known ‘best’ practice.

22 The management of pasture-based wintering systems would need to consider a similar set of principles that are relevant to crop-based wintering approaches. These would ideally include:

(a) Ensuring livestock do not have direct access to streams and sensitive riparian areas.

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4 Two of these farms have free-draining soils and the other two have imperfectly or poorly-drained soils where hay is also provided as an additional feed source and bedding layer.

5 The term grazing intensity is a metric that incorporates the important effects of grazing density (animal numbers per unit area), grazing time and stock type. Relatively high grazing intensities typically occur when winter forage crops are grazed, reflecting the combined effects of high yields of standing plant biomass and the lower rates of feed and space allocation during winter months (Donovan & Monaghan, 2021). High grazing intensities could also be achieved if supplemental feed was imported and used to feed densely-stocked animals on pasture or sacrifice paddocks.

(b) Establishing protective buffer zones in areas identified as critical source areas of contaminant loss, as outlined in paragraph 14 above.

(c) Implementing grazing practices that minimise soil damage, and thus soil erodibility, and help to maintain viable pasture covers.

23 Given our currently poor state of knowledge about the impacts and adoptability of pasture-based wintering systems, some caution is needed before widespread promotion or enforcement of such a wintering approach. Some potential perverse outcomes that could eventuate might include:

(a) Pasture paddocks on poorly-drained soils used for winter grazing could potentially get as badly damaged as paddocks used for winter crop grazing. Given the larger area needed for pasture-based wintering (as described in paragraph 19), these damaged areas of soil could potentially be greater than for a winter crop grazing approach. This is perhaps a worst-case scenario outcome, albeit a plausible one.

(b) Pasture paddocks could be used as sacrifice areas where, enabled by the importation of large amounts of supplemental feed, stock are wintered at grazing intensities similar to those expected for crop-based wintering approaches. The environmental impacts of these scenarios would likely be similar, given the expected soil treading damage and removal of vegetation.

Consideration of the potential risks to soil and water quality of replacing and maintaining pasture on land with slopes greater than 20 degrees

Techniques for pasture renovation or renewal.

24 Pasture renovation methods can be divided into two categories; no tillage and tillage. Within each, there are a range of techniques that can be deployed depending on the management goals that are sought. A description of these approaches is provided in Thom and Barker (1993) and reproduced in brief below.

(a) No tillage.

i. Broadcast seeding over existing pasture. This is called oversowing but is also sometimes colloquially referred to as a “hoof and tooth” approach, denoting the role of the grazing animal for removing existing vegetation and trampling the newly-applied seed into the soil.

ii. Broadcasting seed after suppression of pasture growth with herbicide. This is sometimes colloquially referred to as a “spray and pray” approach.

iii. Direct drilling seed into existing pasture. This is also called over-drilling or undersowing.

iv. Band spraying. This is direct drilling of seed into the existing sward with herbicide applied along the drill row.

v. Blanket spraying and drilling. Seed is direct drilled after the old pasture is killed or suppressed by broadcast application of herbicide.

(b) Tillage (cultivation).

vi. Minimal tillage. This involves broadcasting or drilling seed after light surface working of the soil with a disc, grubber or other implements, with or without the use of herbicides.

vii. Full cultivation. This involves deep working with a range of implements including ploughs, rotary hoes, discs, grubbers, rollers and harrows.

Sediment loss risk associated with drilling new pastures on slopes of over 20 degrees

25 To my knowledge, there is no published research that has quantified the risk of sediment loss associated with drilling new pastures into New Zealand landscapes where slopes exceed 20 degrees. Our only guide is therefore based on first principles, considering some of the key factors that are known to be important drivers of soil erosion and sediment transport.

26 These factors have been thoroughly researched by overseas researchers (particularly those in the US) and incorporated into various iterations of the Universal Soil Loss Equation (Renard et al., 2011) that define the role of at least 5 key factors: Slope (S), Slope Length (L), Rainfall Erosivity (R), Soil Erodibility (K) and Cover (C) factors. For any given location and slope, the two predominant factors that will influence soil losses are ground cover and soil erodibility.

27 The Revised Universal Soil Loss Equation (**RUSLE**) has been recently updated to capture some important effects that are specific to New Zealand’s farmed landscapes, such as the impacts of animal treading damage on soil erodibility and how our forage systems affect soil cover.

28 Thus, in the absence of published measurements of soil losses and suitable process-based modelling tools, the RUSLE framework of Donovan & Monaghan (2021) and Donovan (2022) is probably the most useful tool that can be used to explore the likely direction and magnitude of changes in soil loss risk as slope and management factors change under various farming practice scenarios.

29 Assessment of the soil loss risk associated with drilling new pastures on slopes would require consideration of likely changes in the Slope (S), Cover (C) and Soil Erodibility (K) factors (assuming slope length and rainfall parameters are held constant). To illustrate how these factors influence soil loss risk, calculated soil loss risk is shown as a function of slope in Figure 1 for three management scenarios that have been constructed for this Evidence Statement:

(a) Control - Continual (i.e. un-renovated) pasture with assumed factors of 0.04 for C and 0.029 for K;

(b) Direct drill - A pasture renovated via direct drilling and assuming no consequent increase in grazing intensity; C factor assumed to increase by 13% to account for an assumed 1-month period of reduced soil cover in spring as new seedlings establish;

(c) Direct drill with greater yield - A pasture renovated via direct drilling that delivers a consequent increase in grazing intensity due to a doubling of pasture production; C and K factors are assumed to increase by 13 and 5%, respectively, under this scenario.

30 The most obvious feature of Figure 1 is the strong relationship between slope and soil loss risk. Whilst these two particular pasture renovation scenarios are estimated to increase loss risk by between 10% and 20%, their effects are small relative to the effect of choosing contrasting slope scenarios e.g. loss risk more than doubles for a 20 degree slope compared to a 10 degree slope.

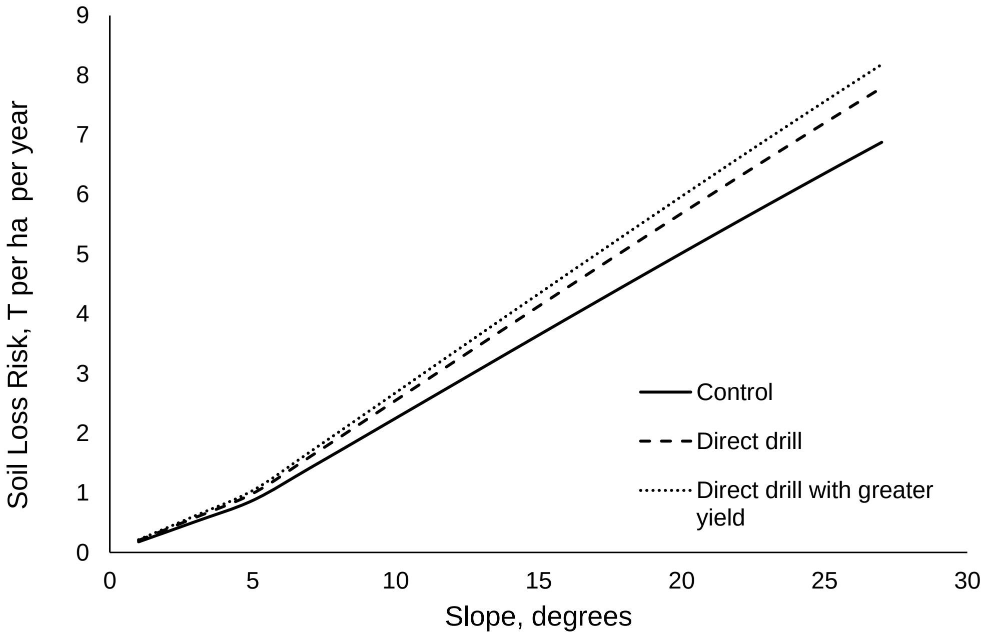

Figure 1. Estimated soil loss risk as a function of slope for management scenarios representing an un-renovated pasture (Control) and a direct-drilled pasture-to-pasture sequence with or without assumed increases in subsequent pasture yields. Constant values for slope Length (1.08) and Rainfall erosivity (700) factors were assumed for all modelled scenarios.

31 It is important to note that the RUSLE framework calculates a soil loss risk that represents the likelihood of soil being mobilized by surficial erosion from water. Some of this mobilized soil may be re-deposited within the landscape prior to reaching a waterway, particularly on concave slopes where reductions in slope angles reduce the velocity and energy of overland flow that has entrained sediment. The soil loss risk values in Figure 1 do not therefore represent the amounts of sediment delivered to water bodies but instead provide an index of ***potential*** soil loss risk.

32 'Spray and pray' and 'tooth and hoof' are colloquial terms that refer to establishment methods that have been used to introduce new plant material into landscapes that are considered un-cultivable, usually due to steep slopes. Aerial application of spray and/or seed, usually via

helicopter, has enabled these methods and resulted in some success, albeit close attention to weed, pest and fertility challenges is required (Lane et al. 2016). The “hoof and tooth” method relies on trampling broadcast seed into the soil when sufficient soil moisture is present that allows improved pasture species to establish. The “spray and pray” approach includes an application (sometimes two) of plant herbicide to remove or suppress less productive resident grasses, thus enhancing opportunities for the newly introduced plant species to establish. This method has sometimes been used to induce a summer fallow period (to conserve soil moisture) and to establish forage crops that can be grazed over the following summer, autumn or winter periods (Lane et al. 2016; Daniell and Buckley 2015).

Sediment loss risk associated with ‘spray and pray’ or ‘tooth and hoof’ methods of pasture and crop establishment on slopes of over 20 degrees

33 Compared to a scenario of continuous pasture cover (i.e. an un-renovated pasture), the “spray and pray” and “tooth and hoof” establishment approaches will likely increase the risk of sediment and particulate P losses due to the increased periods of low or patchy ground cover created during the establishment phase and following occasions when the newly introduced plants may have been hard-grazed (Dodd et al. 2016). There is however no published research that has quantified these effects and their consequences for sediment and P exports from hill land.

34 Based on first principles, relative likely responses could be approximated using the RUSLE framework, assuming that the Cover (C) and Soil Erodibility (K) factors are increased as a consequence of these activities, and slope, slope length and rainfall parameters are held constant. The magnitude of the increase in C will depend on the timing and duration of the establishment phase and the timing(s) and durations of any hard grazing events that follow, particularly if a high-yielding forage crop has been sown and then eaten during the following winter.

35 Changes in values for K are likely to be relatively smaller than for C and will again depend on the type of plant species established and the timing and intensity of grazing that is required to utilise the recently sown feed.

36 The magnitude of the increase in sediment (and P) loss risk is thus heavily dependent on the management context: for scenarios where grass-to-grass pasture establishment occurs, the length of time that the soil is bare or heavily trampled is likely to be relatively low, and the increase in soil erosion risk will be commensurately small e.g. perhaps a 10 – 20% increase[6]. In contrast, where unimproved grassland has been converted to a winter forage crop, soil may be heavily trampled when the crop is grazed and then remain bare for an extended period of time; the increase in soil erosion risk will likely be commensurately large e.g. perhaps a 10- to 20-fold increase[7] in sediment loss risk.

Alternative measures for cultivating slopes of over 20 degrees that lower sediment loss risk.

37 There are at least 3 general management strategies that could be considered for reducing sediment loss risk from eroding landscapes:

(a) Selecting pasture renovation systems that minimise the length of time that soils remain bare, i.e. vegetation cover is maximised. One practical implication of this approach is the importance of establishing a replacement cover crop or pasture as soon as is practically possible following the grazing of a summer-, autumn- or winter forage crop such as swedes or turnips. Given the potentially long periods when soils remain bare after grazing of a forage crop, another consideration would be to explore whether a grazed forage crop can be avoided altogether in the pasture renovation sequence.

(b) Choosing grazing and tillage management practices that minimise soil damage and thus soil erodibility. Some options here include the reduced or no till approaches referred to above.[8] Avoiding hard grazing of renovated pastures or crops on steeper land will also help to minimise soil damage and thus potential erosion.

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6 Assuming a 4 week period of bare soil increases C values by 13%, weighted across seasons.

7 Assuming a mean annual cover factor (C) of 0.35 and a 60% increase in the soil erodibility factor (K) under this management scenario. Values derived from Donovan & Monaghan (2021).

8 See paragraph 24.

(c) Capturing eroded sediment in deposition zones, such as those that often occur in toe-of-slope positions at the bottom of concave slopes. If these areas are suitably large and are protected to ensure good soil infiltration rates are maintained, these areas thus act as buffer zones between areas of eroding land and waterways. The installation of sediment traps is also a commonly used measure to capture eroded soil before it is delivered to water bodies. Because this general strategy relies on reduced flow energy to allow settling to occur, it is more efficient at capturing coarse than fine sediments.

Consideration of the potential risks to water quality posed by sacrifice paddocks

38 I have been specifically asked to comment on the risks that sacrifice paddocks, particularly those used for holding cattle or deer, represent in terms of contaminant loss to water. To my knowledge, there is no published research that has quantified these risks so our only guide is therefore again based on first principles, considering some of the key factors that are known to be important drivers of contaminant loss.

39 By definition, soil and plant conditions in sacrifice paddocks are expected to be badly affected by the effects of animal treading, particularly during wet conditions when these areas are used to preserve other parts of the farm. Treading can potentially have severe consequences for plant cover, soil structure and water infiltration. Exposed and heavily trodden soil will therefore likely result in greater transport of sediment, P and faecal microorganisms in surface runoff.

40 As noted for grazed forage crop areas, relatively large amounts of urinary N can be returned to the soil in sacrifice paddocks, at a time when actively growing plants have been removed due to the effects of animal treading. Paddocks may remain bare, and plant uptake of N remain commensurately low, for relatively long periods and until soil conditions allow a replacement pasture or crop to be established. These combined effects mean that, on a per hectare basis, the risk of N loss to water is potentially very high. The size of this risk will depend on how much feed is provided to animals held on a sacrifice paddock, and consequently how much urinary N is deposited to soil and left vulnerable to loss via leaching or surface runoff.

41 As a note of caution, it is difficult to provide a robust farm-scale assessment of the risks of sacrifice areas due to the confounding effects of relative areas of, and losses from, sacrifice versus protected pasture or crop paddocks. Whilst contaminant loss risks from sacrifice areas are likely very high when expressed on a per hectare basis, these sacrifice areas may represent a relatively small proportion of the farm, and their use will likely reduce the risks of contaminant loss from other “protected“ areas of the farm. The net effect of their use at a farm scale is thus difficult to ascertain using our current state of knowledge.

R. Monaghan

Ross Martin Monaghan
11 February 2022

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