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Costs of wind erosion in the Northern Agricultural Region

Anne Bennett

Department of
Primary Industries and
Regional Development

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Costs of wind erosion in the Northern Agricultural Region

An issues paper

Acknowledgement of Country

The Department of Primary Industries and Regional Development (DPIRD) acknowledges the Traditional Custodians of Country, the Aboriginal peoples of the many lands that we work on and their language groups throughout Western Australia and recognises their continuing connection to the land and waters. DPIRD respects the continuing culture of Aboriginal peoples and the contribution they make to the life of our regions, and we pay our respects to Elders past, present and emerging.

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Disclaimer

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Shortened forms

Short form	Meaning
DPIRD	Department of Primary Industries and Regional Development
ha	hectare
km/h	kilometres per hour
NAR	Northern Agricultural Region
PM	particulate matter
WA	Western Australia

Summary

- To date, the Department of Primary Industries and Regional Development's (DPIRD) estimated opportunity cost of wind erosion for Western Australia's (WA) agricultural region has only included the costs of forgone production income and therefore underestimates the broader costs of wind erosion events.
- This underestimation of costs was the impetus to create a case study to give an indication of the magnitude of the costs of wind erosion from agricultural land.
- Farmers in the Northern Agricultural Region (NAR) were contacted to seek information about the on-farm costs of wind erosion events that occurred in 2020. Seventeen farmers responded to the survey and the average on-farm costs of wind erosion per arable hectare were about $100.
- Local governments and Water Corporation were contacted about the costs to infrastructure from wind erosion in 2020. The total estimated costs were about $100,000. However, the general maintenance programs of the local governments would also include clean-up costs associated with wind erosion. These 'hidden' costs were not included in the estimated costs.
- The estimated health costs for the greater Geraldton area – the only location in the NAR where dust measurements were recorded – were around $3 million (or about $80 per person), and one event contributed 80% of these costs. The total health costs for the NAR arising from wind erosion will be higher because the area and consequently the population affected by wind erosion during 2020 is much bigger than the City of Greater Geraldton.
- Other costs associated with wind erosion were not considered in the case study because of a lack of data. These costs include siltation of waterways, cleaning (businesses and homes), transport disruptions, clogging machinery, sandblasting of infrastructure, potential pollution of food and on-farm water sources, soil movement, weed, seed, chemical and nutrient movement into streams and the broader environment.
- Given the limitations in data collection and accuracy, this paper is intended to provoke discussion in industry and rural Western Australia about the costs and management of wind erosion. More detailed work is needed to accurately reflect the costs of wind erosion.
- The costs are illustrative and cannot be generalised because of their limitations. Costs are in Australian dollars.

1 Introduction

This issues paper uses a case study to indicate the magnitude of the costs of wind erosion from agricultural systems in WA. The findings of this study are intended to generate further investigation into the costs of wind erosion.

In 2022, DPIRD estimated the opportunity cost (forgone production income) from wind erosion for the agricultural region as $62 million. However, the costs of wind erosion extend beyond lost production and can include the costs of reapplying chemicals and fertiliser, reseeding, levelling paddocks, livestock losses and health costs, pasture costs, soil loss, cleaning up moved soil and management costs. There are also off-site costs such as health costs, disrupted transport, road cleaning, cleaning workplaces and houses, and siltation of waterways.

While the cause of wind erosion is relatively well understood, there is generally poor understanding of the actual costs for farmers and the broader community. There are few studies on the costs of wind erosion in WA and the last detailed study was in 1981.

The Northern Agricultural Region (NAR) was used for the case study because it had 3 significant wind erosion events in 2020 and has air quality monitoring. Indicative costs were explored for on-farm costs, health costs and off-site infrastructure costs. A farmer survey was used to investigate on-farm costs of wind erosion, whereas health costs were estimated using research developed from mine sites. Infrastructure costs were estimated through direct contact with local governments and Water Corporation.

The low response rate to the farmer survey and the limited WA-based research attributing on- and off-farm costs directly to wind erosion means the presented values must be considered an example of the potential order of magnitude of the problem and should be interpreted with caution.

2 Background

For wind erosion to occur, 3 factors are needed: erosive winds, exposed soil and detached surface soil. DPIRD recommends a range of management practices to reduce wind erosion risk (DPIRD 2022b):

- install shelter belts and wind breaks to reduce erosive winds
- maintain at least 50% anchored groundcover to reduce the amount of exposed soil
- undertake soil-disturbing practices (e.g. spading, delving) only when the soil is moist, and minimise stock trampling and vehicle disturbance to reduce detached surface soil.

Climate factors contribute to wind erosion risk. Between 1988 and 2018, the NAR experienced an 8% decrease in annual rainfall, decreased rainfall in autumn months and an increased number of hot days (BOM 2022). Climate change projections for the NAR indicate further decreases in rainfall, increased average annual temperature, increased number of droughts, slightly increased wind speeds, more hot days and increased evaporation. These changes in climate factors will contribute to reduced plant cover and consequently increased wind erosion risk (Sudmeyer et al. 2016).

Farmers in the NAR are vulnerable to wind erosion because the region has a high proportion of sandy soils, which are susceptible to wind erosion. Figure 1 shows wind erosion risk for the NAR and was generated using a combination of topography and soil information (van Gool et al. 2005). The map indicates a predominance of land with a high percentage of high to extreme wind erosion risk towards the coast.

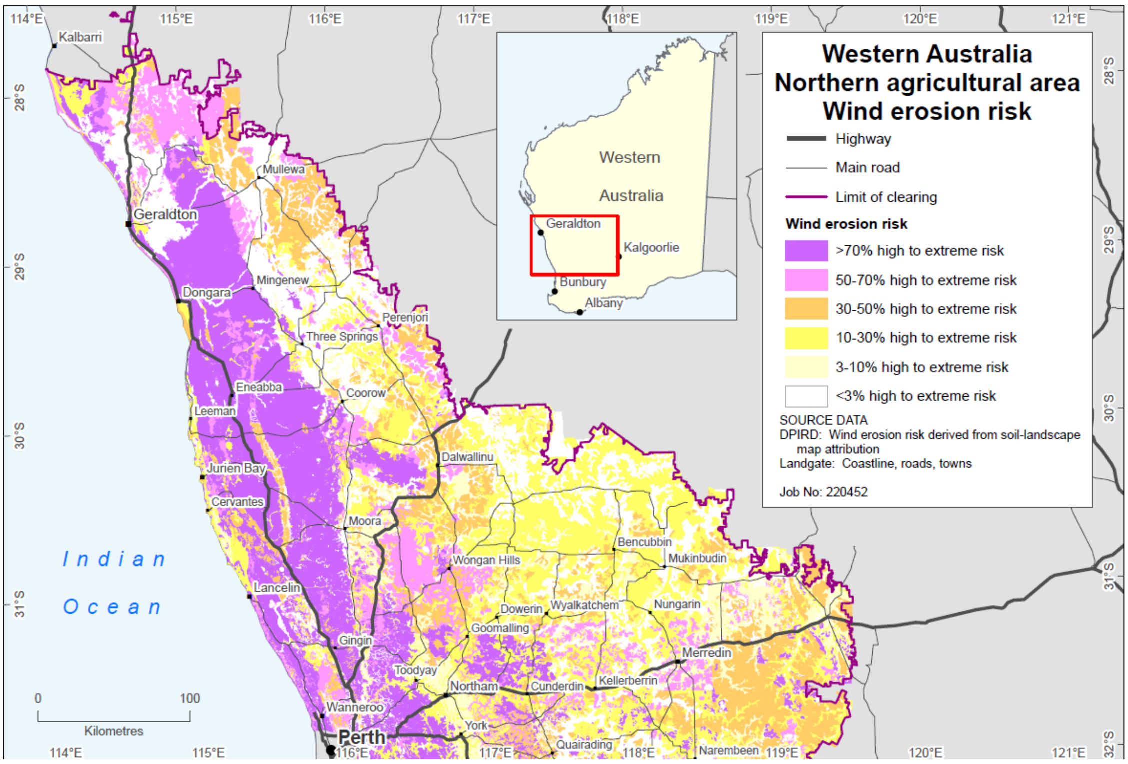

Figure 1: Areas at risk of wind erosion in the Northern Agricultural Region

Erosive winds – winds over 28 km/h – frequently occur in the NAR. For instance, between 1 March 2020 and 28 February 2021, for the 356 days of available data for maximum wind gust, 353 days had gusts of 28 km/h or higher (Figure 2). Although there were high winds throughout the year, the risk of wind erosion is greater in summer when there is less groundcover and less moisture in the soil.

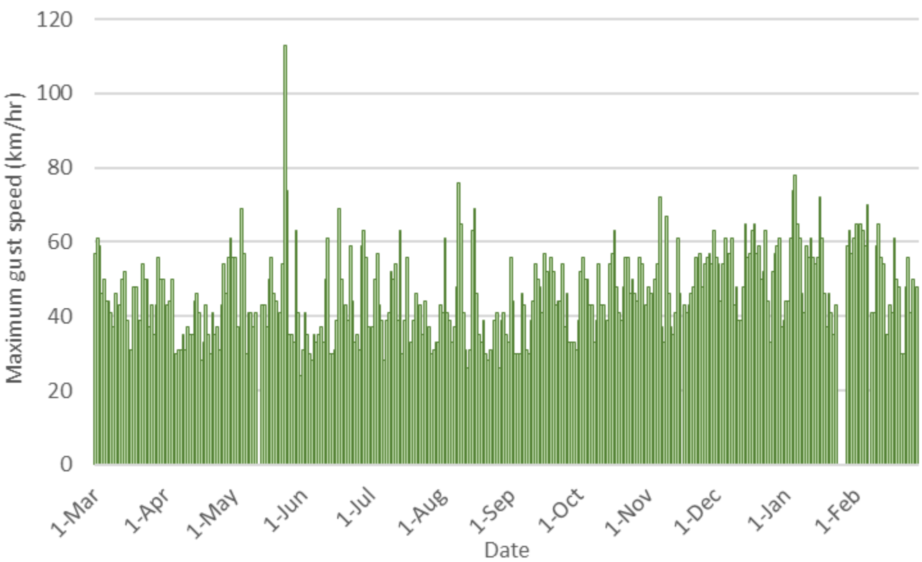

Figure 2: Maximum wind gusts in Geraldton, 1 March 2020 to 28 February 2021

Between December 2019 and December 2020, farmers in the NAR experienced several wind events that resulted in visible soil erosion. During this period, 2 significant erosion events occurred (30 April and 24 May 2020) that resulted in reduced visibility due to high levels of dust in the air (Figure 3).

30 April 2020 24 May 2020

Figure 3: Photos taken on days of high wind erosion and reduced visibility as a result of dust in the air (Photo: P Findlater)

3 Methods

This study investigated the possible costs of wind erosion events in the NAR from December 2019 to December 2020 to get an indication of the costs of these events to farmers and the broader community. Studies investigating significant wind erosion events in Australia estimate the off-site costs to be 1.5–4.5 times the costs of on-farm damage (Williams and Young 1999; Tozer and Leys 2013).

For this study, data was collected from a range of sources. Farmers from the Northern Agri Group and Mingenew Irwin Group were surveyed about the costs of wind erosion incurred on-farm (Appendix A). Initially, a series of face-to-face surveys were to be undertaken; however, COVID restrictions resulted in an online survey using Survey Monkey. Health costs were estimated using air monitoring data from Geraldton and an equation cited by Toxikos in work they undertook for Department of Health (WA) on dust in Port Hedland (DoH 2016). Local governments and Water Corporation were contacted directly via phone or email regarding any costs they may have incurred because of the wind erosion events.

Limitations of this work – such as scale, limited ability to estimate off-site costs and the farmer survey size being very small – means the results cannot be used as an accurate representation of costs for the area, although it does indicate a possible order of magnitude. Consequently, the figures can be considered indicative only. Further investigation needs to be done to more accurately estimate the costs of wind erosion on- and off-farm.

4 Estimated on-farm costs: $100/ha

4.1 Background

In 2019, DPIRD estimated the annual on-farm opportunity costs (forgone production income) of soil constraints in WA's agricultural areas (DPIRD 2022a).[1] Wind erosion had an average annual estimated opportunity cost of $62 million between 2014–15 and 2018–19 (Table 1).

Table 1: Estimated annual opportunity costs of soil constraints in WA's agricultural areas

Soil constraint	Estimated annual opportunity costs 2009–10 to 2013–14	Estimated annual opportunity costs 2014–15 to 2018–19
Subsoil acidity	$1,507m	$1,718m
Sodicity	$577m	$744m
Soil salinity	$519m	$686m
Subsoil compaction	$517m	$656m
Water repellence	$362m	$461m
Transient salinity	$91m	$97m
Wind erosion	**$50m**	**$62m**
Waterlogging and inundation	$35m	$46m
Water erosion	$3m	$3m

m = million

Note: These costs cannot be added together because many constraints interact and occur simultaneously. The opportunity costs are maximums, and the methodology assumes each constraint is the only one present. For instance, if acidity is already pruning the roots, then compaction will have a minimal further effect on yield.

Source: DPIRD (2022a)

When broken down to a regional level, the estimated costs of wind erosion were estimated to be $18 million per year (based on 2014–15 and 2018–19 values) for the 4.8 million hectares identified as at risk in the NAR (or around $9 per hectare identified as at risk of wind erosion). At the time of analysis, around 60% of land was cropped and 40% was pasture for livestock. These figures assume a wind erosion event resulting in an average yield reduction of 63% would occur once every 10 years to 60% of the land in the NAR.

The $18 million figure only estimates the cost of forgone production income. It does not consider the costs of amelioration (e.g. reseeding or reapplying fertiliser or herbicide). Therefore, the on-farm costs are likely to be much higher. On-farm costs of wind erosion can include costs associated with reapplying chemicals and fertiliser, reseeding,

[1] Forgone production income only includes the loss of production in the year wind erosion occurs. It does not include forgone income due to lost production in future years or costs such as lost topsoil, imported weed seeds, loss of fertilisers or loss of herbicides.

levelling paddocks, lost yield, livestock losses and health costs, pasture costs, soil losses, loss of soil organic matter and soil carbon, cleaning up moved soil and management costs.

Unlike the other soil constraints listed in Table 1, soil loss through wind or water erosion can have off-site costs, and potentially more frequent and higher remediation costs. Salinity also has off-site costs.

Pimentel et al. (1995) also note there are energy costs associated with relevelling or reworking the land, energy costs and greenhouse gas emissions associated with producing fertilisers and chemicals that need to be reapplied, and the energy used for reapplication.

Goddard et al. (1981) estimated the total on-farm costs associated with a significant wind erosion event in Jerramungup (WA) were about $140 per arable hectare – $82/ha for cropped land and $58/ha for land in pasture for livestock.[2] This work involved in-depth face-to-face interviews with farmers in the Jerramungup region.

4.2 Indicative average on-farm costs estimated from farmer survey: ~ $100 per arable hectare

The sample data regarding on-farm costs presented below relates directly to the 17 received survey responses; it is indicative only and cannot be generalised because of the small survey size and the heterogeneity of the businesses participating.

On average, 2,600 ha of each property experienced moderate or severe wind erosion, and 2,000 ha of each property experienced more than one wind erosion event.

The survey responses revealed on-farm costs of wind erosion have an average value of about $100 per arable hectare and a median value of $71/ha. However, there was significant variance – from as low as $2/ha to $400/ha. This variance may be due to a range of factors, including differences in wind gust strength due to location or topography, differences in severity of effects of wind erosion, differing farm practices, presence of wind breaks and the types of responses used to remediate damage.

Applying the average costs of $100/ha to the modelled at-risk farmland of the NAR (2,160,000 ha) results in regional on-farm costs of wind erosion of $216 million, which is significantly greater than the $18 million opportunity cost for the NAR estimated by DPIRD (2022a).

Note: The 2018 growing season had a late start and an early finish; little rain fell after August (GIWA 2019). Below-average annual rainfall was experienced in many parts of the NAR (BOM 2019). The 2019 growing season also had very much below-average rainfall (BOM 2020). These 2 low rainfall seasons resulted in reduced groundcover for

[2] These are 1982 dollar figures. Since 1982 and 2021 there has been an average annual inflation rate of 3.4%. Using the RBA inflation calculator, these figures in 2021 dollars are equivalent to $520 per arable hectare – $304/ha for cropped land and $216/ha for land in pasture for livestock. To note, since 1982 there has been considerable changes to farming systems, practices and prices.

2020. Even with best management practice, wind erosion would likely still have occurred on many properties if high winds were experienced.

Further detail on the survey is in Appendix A.

5 Estimated off-farm costs: $3,100,000+

Economic studies looking at wind erosion events in Australia estimate the off-site costs of wind erosion to be 1.5–4.5 times that of on-farm costs (DAFWA 2014).

Tozer and Leys (2013) identify costs associated with health, transport, cleaning (local governments, businesses and private residences) and environmental damage.

Estimating the breadth of off-farm costs was not possible in this study. Instead, this study only investigated costs associated with health and some of the costs of cleaning and repairing roads because of the difficulty in obtaining other data.

5.1 Infrastructure: ~$105,200+

Typically, infrastructure costs are incurred after a large wind erosion event; these costs mainly relate to clean-up and repairs (Tozer and Leys 2013). These costs often go unnoticed (or unacknowledged) for low-level wind erosion events. Clean-up costs are also highly localised.

Given the costs are limited only to local governments and Water Corporation, the costs are indicative only.

5.1.1 Local government

The wind erosion event on 24 May 2020 was the only event in the study period to generate a specific response from local governments in the NAR, and road clean-up was the only issue requiring specific attention. The estimated costs incurred by the City of Greater Geraldton, Shire of Mingenew and Shire of Irwin totalled $105,100.

Issues, such as sand movement onto roads, from other wind erosion events are included as part of the local governments' annual maintenance program, not as a separate costing, and consequently were not able to be itemised for this study.

5.1.2 Water Corporation

Water Corporation did not incur any cleaning costs because their tanks are fully enclosed.

Costs for cleaning water supplies other than those managed by Water Corporation were not investigated in this study.

5.2 Health: ~$3 million

Wind erosion is known to cause health issues. Increases in atmospheric particulate matter (PM) arising from wind erosion affects the health of communities. PM pollution, including PM from natural sources such as windblown dusts, correlates to increases in all forms of mortality as well as in cardiovascular and respiratory related illness

(Kotsyfakis et al. 2019). The most susceptible people are those over 65 years of age, children, and people with pre-existing cardiovascular or respiratory disease (DoH 2016).

Using PM_{10} and $PM_{2.5}$ data from the Department of Water and Environmental Regulation (DWER) monitoring site in Geraldton, exceedances in PM_{10} occurred on these dates of the study period: 11 December 2019, 9 January 2020, 30 April 2020 and 24 May 2020.[3,4] A $PM_{2.5}$ exceedance occurred on 24 May 2020. DWER (2021) suggest the most likely cause of these exceedances was windborne dust. Data for 25 May 2020 were missing. Exceedances were identified using Australia's National Environmental Protection Measure (NEPM) which sets exceedance levels as 50 μg/m^3 for PM_{10} and 25 μg/m^3 for $PM_{2.5}$.

Only the City of Greater Geraldton was considered in this study because this is where the PM data were collected. However, the area and therefore the number of people affected by the wind erosion events investigated in this study is bigger than the City of Greater Geraldton, and consequently the estimated costs will likely be higher (NACC 2022).

To calculate the costs of wind erosion, hospital admission data could not be used because the population of the City of Greater Geraldton (about 38,500) is considered too small to pick up signals. Instead, modelling based on large population studies was used to give indicative costs (Table 2).

Using the data in Table 2, the costs of the 4 wind erosion events was estimated using the equation developed by Toxikos (DoH 2016) when assessing the health costs of air borne PM_{10} particles in Port Hedland:

> *Increase in risk for each health outcome = exposure response function per unit increase in pollutant concentration × pollutant concentration × baseline incidence rate per 100,000 population*.

A limitation of this concentration response function is it is based on urban air pollution studies as currently there are no concentration response functions for mineral dusts from wind erosion.

The total costs of wind erosion for the 4 days where PM_{10} levels exceeded guidelines were estimated to be about $3 million or around $80 per person for the City of Greater Geraldton (Table 3). The data also show that for an event with very high winds, such as the event on 24 May 2020, the potential health costs can be very high and around 80% of the total costs were generated by this event alone. Comparatively, wind erosion events with lower wind speeds have lower associated health costs.

These numbers only include the costs of events where PM_{10} standards are exceeded. There will be health costs throughout the year as fine particles become airborne because of wind erosion, but where the NEPM standards are not exceeded. There could also be other health costs associated with issues such as elevated $PM_{2.5}$ levels or

[3] PM_{10} refers to particles with a diameter of 10 micrometres or less; $PM_{2.5}$ refers to particles with a diameter of 2.5 micrometres or less.

[4] DWER accepts no responsibility for the accuracy of the information or its suitability for this study.

on-farm human and livestock water and food sources being polluted with farm chemicals.

Table 2: Estimated health costs of the 4 wind erosion events with PM_{10} exceedances in the study period of December 2019 to December 2020

Health issue	Response function[a]	Baseline incidence per 100,000 population (PM_{10} average)[b]	Baseline incidence per 38,500 population[c] (adjusted PM_{10} average)	Daily incidence	Estimated costs per incident[d]
Premature mortality (all causes)	0.002	551	212	0.58	$4,486,062
Cardiovascular	0.002	1,541	593	1.63	$7,473
Respiratory	0.003	1,916	738	2.02	$7,564
Asthma	0.015	52	20	0.06	$732

a Data sourced from DoH (2016), p 46.

b Data sourced from Borchers Arriagada et al. (2020), Appendix, p 3.

c Population of City of Greater Geraldton.

d Data sourced from Borchers Arriagada et al. (2020), Appendix, p 6.

Table 3: Estimated health costs of wind erosion events exceeding National Environmental Protection Measure standards in 2020 for the population of the City of Greater Geraldton

Wind erosion event date	Estimated costs (to the nearest $10,000)[a]	PM_{10} reading
11 December 2019	$190,000	52.96
9 January 2020	$230,000	59.44
30 April 2020	$210,000	56.91
24 May 2020[b]	$2,370,000	464.76

a These figures are estimates and need to be interpreted with caution. They give an example of the potential order of magnitude of the problem.

b 25 May 2020 also experienced visible wind erosion, but there was no PM_{10} reading that day so costs could not be estimated.

Further research by an expert in air pollution health effects and costs is needed to determine valid health costs of wind erosion.

5.3 Environment

Environmental costs were not estimated because no data were readily available. Costs could include movement of soil, weeds and seeds, siltation of waterways, covering of native vegetation with soil or dust, and movement of chemicals and nutrients into waterways and food chains.

5.4 Other

Other costs attributable to wind erosion that were not estimated in this study could include the expense of cleaning for those off-farm households and businesses, road safety concerns due to reduced visibility and associated motor vehicle accidents, absenteeism, and grounded aircraft (Tozer and Leys 2013).

Because of COVID-19 restrictions and lockdowns, aircraft were not flying on 24 and 25 May 2020 when the most significant wind erosion event occurred; therefore, there were no costs for grounded aircraft because of poor visibility owing to dust. Road traffic was also reduced because of COVID-19 travel restrictions so any possible increase in road traffic accidents resulting from poor visibility due to dust may have been reduced or avoided.

Absenteeism from the workplace was not investigated – this may have been lower than normal because of COVID-19 restrictions and many people working from home.

6 Discussion

There have been very few studies undertaken in WA seeking to estimate the on-farm and off-farm costs of wind erosion.

DPIRD (2022a) estimated the opportunity cost of forgone production income from wind erosion for WA's agricultural areas at $62 million and for the NAR at $18 million annually for the 5 years to 2019. The figures only include the cost of forgone production income and do not include costs of on-farm remediation, future lost production or off-farm costs. This study surveyed a small group of farmers about these additional costs and the data received suggests total wind erosion costs for the NAR in the period December 2019 to December 2020 could be more than $200 million, more than 10 times that of DPIRD's opportunity cost estimate. This result shows that including costs beyond lost production means that on-farm costs significantly exceed the opportunity cost estimated by DPIRD.

Off-farm costs associated with wind erosion, such as environment, transport and cleaning, were not estimated in this study because of the difficulty in obtaining data that would enable an estimation. However, this study was able to take an indicative look at the potential health costs associated with wind erosion events for the City of Greater Geraldton and revealed potential costs of around $80 per person.

Research estimating off-farm costs of wind erosion in WA's agricultural areas could not be found. However, previous studies in Australia suggest off-farm costs of wind erosion are between 1.5 to 4.5 times that of on-farm costs. Using this rule of thumb, annual off-farm costs for the study period could be between $324 million to $972 million for the NAR.

This study revealed there are a range of limitations in estimating wind erosion costs in the NAR. The lack of cost estimates limits the ability of government, communities and farmers to effectively respond to this issue. The data in this study show existing cost estimates are likely to be significantly underestimated. Consequently, research and extension in wind erosion has likely been underinvested.

7 Recommendations

It is recommended a comprehensive investigation of wind erosion costs is undertaken to better understand what costs are incurred both on-farm and off-farm to provide better cost estimates. Teasing out and estimating off-farm costs, together with a more accurate estimation of on-farm costs, will help to improve government intervention and investment in wind erosion. This work could include:

- a more comprehensive survey of farmers to get a larger dataset and therefore a more accurate estimate of on-farm costs of wind erosion
- harnessing available monitoring information and datasets, and complementing these with new datasets where possible, to develop an indicative value of the off-farm costs of wind erosion
- seeking an expert in air pollution health effects and costs to determine valid health costs of wind erosion.

In the first instance, these actions would be best undertaken in a focus area. Climate change projections and susceptibility of the soils to wind erosion in the NAR make this region an excellent focus for such a study.

Appendix A Survey results

Farm details

Number of respondents

A total of 17 farmers, via Survey Monkey, which is less than 10% of the members of the 2 grower groups.

Location of respondents

From postcodes 6525, 6526, 6532, 6522, 6535.

Area managed by survey respondents

Total was 125,568 ha; average was 7,386 ha

Arable hectares managed by survey respondents

Total was 111,936 ha; average was 6,584 ha

Percentage of arable area in crop

On average, 78%. However, there was one livestock-only farmer, one farmer had 35% in crop, two had 50% in crop, one had 70% in crop, and the remaining 12 farmers had 80% or more in crop.

Area that experienced a moderate or significant wind erosion event between harvest 2019 and harvest 2020

Average was 2,600 ha (range 25–12,000 ha). Data came from 14 respondents.

Area that experienced more than one wind erosion event between harvest 2019 and harvest 2020

Average was 1,990 ha (range 50–12,000 ha). Data came from 11 respondents.

Cropping

On average, around 20% of cropped land incurred a yield penalty, which averaged $210 per affected hectare. Additionally:

- on average, 730 ha was resown per farm at an average cost of $57/ha
- 3 respondents reapplied chemical at an average cost of $28/ha
- 3 respondents reapplied fertiliser at an average cost of $50/ha
- 14 respondents had areas of their property that were sandblasted and not resown
- other reported costs included levelling paddocks, loss of nutrients, increased weed burden, increased weed control costs (about $60/ha), penalty due to decreased protein (about $70/ha) and increased workload at the time and in the future.

Area of cropped land that experienced a yield penalty

Average was 1,144 ha (22%) (range 5 ha [<1%] to 7,000 ha [50%]). Data came from 15 respondents.

Estimated yield penalty

Average was $210/ha (range $50–$400/ha).

Area resown

Average was 730 ha (range 20–7,000 ha). Data came from 14 respondents – 2 respondents reported 0 ha and this value was included; the livestock-only farmer did not have a value; 2 respondents did not answer. One respondent commented ‘Didn’t reseed but probably should have for cover’.

Cost of resowing

Average was $57/ha (range $25–$100/ha) based on the 5 respondents who resowed. Twelve respondents did not report resowing and were not included in this calculation.

Area requiring reapplication of chemical

The average area requiring reapplication of chemical was 17,200 (range 200 to 14,500 ha). Data came from 3 respondents. One respondent commented that time spent reseeding meant that post-emergent sprays were delayed and consequently application rates were higher.

Cost of reapplying chemical

Average was $28/ha. Data came from 4 respondents.

Area requiring reapplication of fertiliser

Average was 283 ha (range 100–550 ha). Data came from 3 respondents.

Cost of reapplying fertiliser

Average was $50/ha (range $35–$60/ha).

Area that was sandblasted and not resown

Average was 920 ha (range 3–6,500 ha). Data came from 14 respondents. Comments made were ‘small patches not worth reseeding’ and ‘all sandplain’.

Other cropping costs

Other cropping costs reported by respondents:

- levelling of paddocks and associated equipment hire or purchase
- loss of nutrients for which it is difficult to quantify the cost
- increased weed burden from seeds blown onto property
- increased weed control costs of around $60/ha
- lower protein in resown crops giving a yield penalty of around $70/ha
- increased workload associated with smoothing areas.

Livestock

The total cost of livestock production lost to wind erosion averaged $260,000 (range $30,000–$900,000). Livestock farmers reported contributing costs including:

- buying feed (average cost $22,750)
- re-establishing pastures (average cost $200/ha)
- agistment.

Livestock farmers also reported that it would take about 5 years to get back to where they were before the wind erosion events in 2020 for all aspects of livestock production.

Estimated total cost of lost production

Average was $30,000 (range $30,000–$80,000). Data came from 4 respondents.

Estimated total additional livestock health-related costs

No livestock health-related costs were reported.

Estimated total additional feed costs?

Average was $22,750 (range $3,500–$35,000). Data came from 4 respondents.

Area and cost of pasture requiring re-establishment

Average area was 125 ha at an estimated cost of about $200/ha. Data came from 2 respondents.

Total estimate of other livestock costs (e.g. agistment, buying and selling stock)

Agistment cost was $10,000. Data came from 1 respondent.

Time to return to where you were for all aspects of livestock production before the wind erosion events in 2020

Average time expected to be 5.5 years (range 2–10 years). Data came from 4 respondents.

Management

Eighty per cent of respondents said they regularly factored wind erosion into management and decision-making.

Respondents estimated it took an average of 55 hours to coordinate a response to wind erosion events that happened on their property.

Other issues reported as requiring attention were removing trees and sand on fences; increased overall costs due to resowing including increased seed price; difficulty removing fine dust; increased stress on machinery; loss of plants on roadsides and in the bush; loss of wind breaks; and loss of tree plantings potentially due to pre-emergent chemical movement.

Some respondents reported feeling increased levels of personal stress.

Respondents were asked if a series of known issues affected them. Figure A1 illustrates their responses.

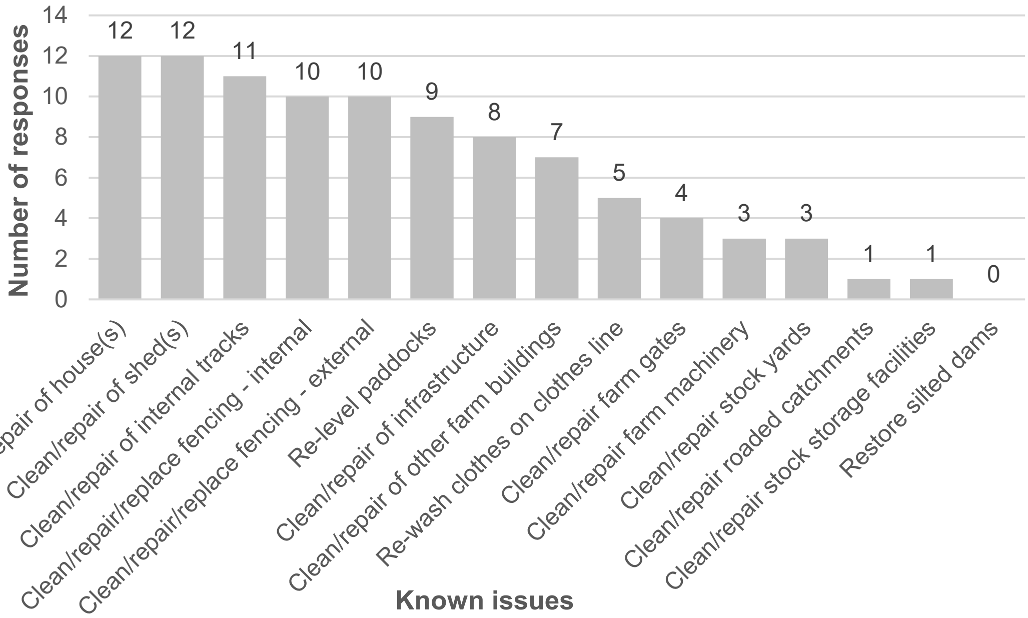

Figure A1: Histogram of responses to specific issues related to wind erosion

Estimated time for planning and coordinating a response to soil erosion on property

Average was 54 hours (range 4–200 hours). Data came from 12 respondents. One respondent commented that time is still being allocated to this issue.

Estimated cost of planning and response

The answers to this question were unclear and are not included.

Other issues (answers are grouped into themes)

- Checking and removing trees and sand on fences.
- Increased price of crop seeds for resowing.
- Weed seeds blown around and onto the farm.
- Difficult to remove fine dust from homes (e.g. swimming pool).
- Pre-emergent chemical moved and caused issues such as loss of trees in the bush and on roadsides, loss of wind breaks and loss of tree plantings.

Other economic impacts from wind erosion, including psychological distress requiring a sick day(s), or illness (answers are grouped into themes)

- Personal stress at the time and ongoing.
- Increased stress on machinery because of an increase in the uneven land surface created by sand scouring and new deposits.

Respondents were asked if they factored wind erosion into their management or decision-making on a regular basis

Yes – 12 respondents (80%).

No – 3 respondents (20%).

Respondents were asked if they will do things differently in the future because of wind erosion during 2019/2020 season

Data came from 14 respondents; answers are grouped into themes.

No: already doing best practice management for wind erosion.

Yes:

- Use more resilient pasture species.
- Reduce soil-disturbing activities (e.g. spading, deep ripping and cultivation) before rain.
- Stock paddocks more cautiously to avoid putting pressure on weak paddocks.
- Delay seeding until rain.
- Cut stubble higher.
- Retain more groundcover.
- Trial green manure crops on sandplain.
- Reduce legumes because they have poor stubble retention.

Other comments

Comments have been grouped into common themes: weather, management practices and other.

Weather

- Poor season in 2019 resulted in less groundcover, increasing risk of wind erosion in 2020.
- Strong winds meant even with all best practice management in place, the soil still blew.
- Advance warnings about strong winds coming would be helpful so livestock can be moved to less-exposed sites.
- Wind was from a different direction to normal.
- It was a very rare extreme wind event [on 24 May 2020]. We noticed stubble in paddocks collected sand and created lumps and mounds, and bare paddocks blew flat.
- It was a 100-year event [on 24 May 2020]. We have a steady program to gravel roadways etc. to minimise drift on fences etc. We have not burned a paddock in about 8 years.

Management practices

- Water-repellent soil has caused depleted pasture cover allowing wind erosion to occur. Deep inversion ploughing seems to be solving this issue.
- Stubble cover was not enough after amelioration work and a poor season in 2019.
- We did not dry sow deep-ripped ground until rain came.

Other comments

- Sowing direction affects wind erosion risk.
- Active land management like covering scalds with something like hay, sowing into scalded areas without spraying is an effective strategy to improve soil stability and reduce wind erosion.
- Gravelling road networks reduces wind erosion.
- Drought in 2019 compounded the effects of multiple wind events in early 2020, not just the big blow. Lots of very poor lupin stubbles in 2019 left a lot of paddocks already very exposed. Need research trials for better build-up of stubble legumes and rotations and ideas.

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