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Projected impacts of salinity on dryland property values in South West Australia

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TABLE OF CONTENTS

Abstract

The goal of this analysis is to predict the impacts of salinity on property values in the unirrigated, predominately cropping land in the south-west agricultural region of Western Australia. The method applied is statistical analysis of the relationship between salinity and property values in data from the recent past. Estimates suggest that if we can avoid salinisation of salt free cropping land holding other factors constant, we can avoid a reduction in land values of anywhere between 30% and 95%. In terms of dollar values and relative to the average land value per hectare in this study of approximately $1500, that amounts to savings of between $450 and $1425 per hectare.

1. Method

The goal of this analysis is to predict the impacts of salinity on property values in the unirrigated, predominately cropping land in the south-west agricultural region (SWAR) of Western Australia (see Figure 1). The method applied is statistical analysis of the relationship between salinity and property values in data from the recent past. We model changes in *relative* production caused by salinity, by focusing on marginal impacts. The hypothesis underpinning this approach is that given competitive land markets, the impact of salinity on property values reflects the expected present value of changes to future profitability. Because factors such as price change over time, no attempt is made to predict the *absolute* future property value. Rather, following the statistical approach of Mendelsohn, Nordhaus and Shaw (1994) (MNS), which they dub the "Ricardian" method (a particular application of Hedonics), we examine the relationship across space of differences in salinity levels and agricultural property values.

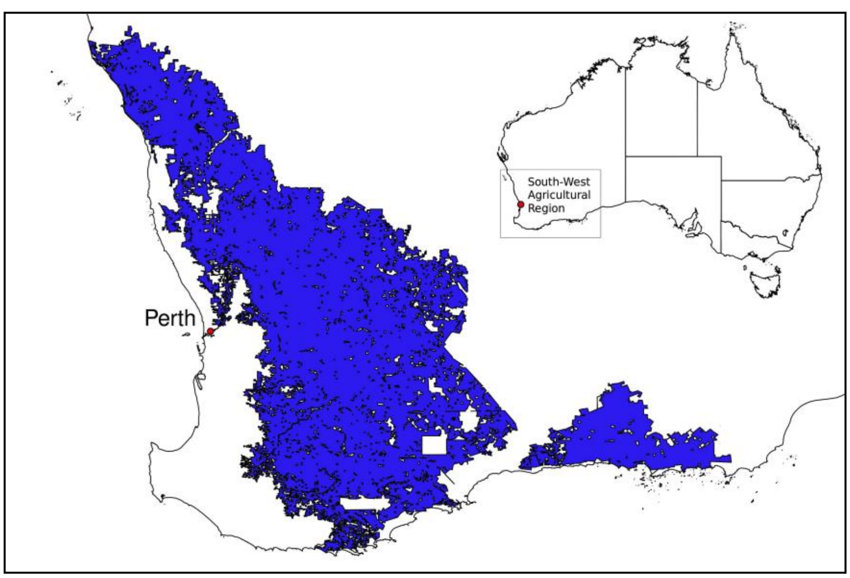

Figure 1. Unirrigated cropping land in the South West Agricultural Region of Western Australia

1.1 Why the Ricardian or hedonic approach?

There are at least two alternatives to the hedonic approach including the production function or experimental approach and the computable general equilibrium (CGE) approach. The CGE approach models economy wide changes by sector in response to changing economic incentives. An advantage of the CGE approach is it effectively makes price (or price determinants) an endogenous variable in the model. However, a key problem with CGE is that it relies on high levels of aggregation of diverse sectors into a single, in this case, representative farm (Schlenker, Hahnemann & Fisher 2006 (SHF)). This is akin to modeling each farm, regardless of its location or the type of crop it produces as an identical unit. Given that we are looking at relatively fine-scale data where spatial heterogeneity from farm to farm and even field to field is important, aggregation bias renders CGE unsuitable (Hansen and Jones, 2000).

The production function approach involves fully specified models that account for all variables affecting agricultural yield. An example is the Australian Agricultural Production Systems Simulator model (APSIM) that incorporates modules for plant, soil and management driven by actual or projected daily weather data (Keating et al 2003). Estimates of climate change based on these experimental models (e.g., Howden & Jones 2004) are useful because they account for all factors affecting yield including those that are beyond the control of the farmer. Hence these models are purged of bias: there are no omitted variables to confound the estimates. However, a disadvantage associated with fully specified models is that, by definition, they do not allow for farmer adaptation whether it be altered fertiliser application or the decision to plant an alternative crop or the decision to continue cropping at all (MNS: 754) in the face of various perturbations.

Therefore, the change in the expected value of the left hand variable given a change in any of the right hand independent variables literally holds all other right hand variables fixed. In the literature this is referred to as the 'dumb farmer' effect alluding to the notion that only a dumb farmer would continue to farm using inputs that by definition must be sub-optimal (MNS: 753). As a result, estimates using experimental models tend to be biased downward (e.g., in the face of a positive shock, the net effect is underestimated or the gross damage is overestimated).

The Hedonic approach

The Hedonic approach models climate change by regressing the value of agricultural land (i.e., the market value derived as a function of profit and a capitalisation ratio, see for example SHF (114)) in any given year on salinity while controlling for soil, climate, location and any other factors that might be likely to effect agricultural land value. By modelling the value of agricultural land as opposed to crop yield, which is implicit in the value of land, this approach effectively allows for a large variety of adaptations hence avoiding the dumb farmer effect. Put another way, a key advantage of the hedonic approach is that land values reflect the most profitable use of land. One does not need to explicitly model the land use choice, because the optimal choice is already embedded implicitly within the model. In this sense, the hedonic approach requires less information than alternative production function techniques (but conversely is subject to potential issues of omitted variable bias), which require specification of the crop produced. In addition, the changes in land values more directly tie to rural welfare than do changes in yields of specific crops. Further, in contrast to the highly aggregated CGE models, the hedonic function enables calculation of the direct impact of salinity events down to as fine a scale as your data allows. For example, down to the farm or regional scale.

2. Data sources

2.1 Property values

We have a sample of sales price and land data from the SWAR. The database includes sales price, year, land area, significant improvements, geocoding, and zoning. The sales data is current to 2008, however given limitations of our salinity data, we restrict this analysis to 5 years between 2003 and 2007 inclusive. Unirrigated agricultural properties exceeding 100 ha were used in the analysis. After taking this into consideration the average property was approximately 820 hectares and valued at 2008 prices was worth approximately $960,000. The average price per ha was about $1,540.

2.2 Historical climate

For the property value analysis, historical climate averages for agricultural areas throughout Australia were constructed from station-level data from the Bureau of Meteorology. The ANUSPLIN surface-fitting statistical package (Hutchinson, 2004) was used to obtain location-specific climate averages. Fitted temperature data is calculated based on data from 1,345 weather stations for the period 1977-2006. Rainfall data is calculated based on data from 10,903 stations for the same period.

2.3 Soil

The soil data provides polygon coverage for the entire south west agricultural region and was obtained from the Australian Soil Resource Information System (ASRIS) and reflects information available in the Western Australian Department of Agriculture's (WADA) map unit database in 2005. We use various indicators to control for soil productivity including:

- coarse fragments in the soil surface layer;
- surface layer organic carbon;
- surface layer pH;
- soil clay content; and,
- minimum hydraulic conductivity up to 2 metres depth.

2.5 Geography

Geoscience Australia (2009) provides access to a number of broad topographical datasets. We have used the 1:10Million GEODATA TOPO 2002 dataset to extract road and coastline data.

2.5 Land use

Although much of our sales data contains some information on land use, the classification is incomplete and inconsistent. The Australian Collaborative Land Use Mapping Programme (ACLUMP, 2007) provides comprehensive, detailed and consistent land use mapping for the entire country (except parts of NSW at time of writing) at scales varying from 1:25,000 to 1:250,000. These data are necessary to identify properties in dryland agricultural uses such as cropping or pasture.

2.6 Population

Population density data was derived from data from the 2006 census supplied by the Australian Bureau of Statistics (ABS). This data was matched to properties using Statistical Local Area geometries.

2.7 Salinity

Salinity data was obtained from the same source as the soil data (ASRIS and WADA). We use indicators for current soil surface salinity levels and a salinity hazard or future risk indicator. Due to the potentially highly variable nature of surface salinity we have restricted our analysis to five years between 2003 and 2007 centred on the date at which the salinity data is current (i.e., 2005).

3 Key variables

Table 1. Summary statistics across 2883 observations included in the regression

	Variable	Mean	Standard Dev.	Min	Max
Salinity	*extreme*	0.8%	3.2%	0%	37.8%
	high	2.0%	3.7%	0%	42.7%
	medium	4.0%	7.9%	0%	77.7%
	slight	21.5%	20.4%	0%	100.0%
Climate	*Annual Temperature*	17.5	1.1	15.5	20.9
	Annual Rainfall	435.5	105.7	308.4	783.3

3.1 Salinity

Salinity refers to the salt content of a body of water or a piece of land (Ghassemi et al 1995). Salinisation is the process that increases salinity. Areas that are naturally high in salt for whatever reason except those resulting from direct human influence are referred to as areas of primary salinisation. Secondary salinisation refers to salinisation caused subsequent to human modification of the landscape (Ghassemi et al 1995: 31). For example, clearing deep rooted, perennial vegetation (i.e., trees) for annual crops is a common cause of secondary salinisation by increasing the flow of water (the recharge rate) to the water table. As the recharge rate increases, the water table tends to rise liberating salt stored deep within the soil or in the water itself into the root zone of overlying plants.

Salt interrupts plant growth in a number of complex and deleterious ways. For example, plants acquire water via osmosis. Osmosis describes the movement of water across a semi-permeable membrane (impermeable to the solute, but the solvent - water - can pass either way) from a solution of low solute concentration to one with high solute concentration. If the concentration of salt in the soil exceeds that within the plant, osmosis clearly becomes a life threatening liability (for an overview of salinity effects on plants see Parida & Das 2005). The physical change at the surface wrought by salt lying in the root zone or on the surface itself (salt scalds) can be in stark contrast to that prevailing prior to salinisation. Vegetation is less productive, taking on a stunted appearance. Severe salinisation effectively renders productive land barren (see table 2).

3.1a - Surface Salinity

Estimates suggest that anywhere between 1 and 1.8 million hectares (ha) of land in

Western Australia are currently affected by salinity (Pannell and Ewing 2006). Approximately 6% of the Western Australian agricultural region is effected by greater than or equal to moderate levels of salinity (Van Gool, Vernon and Runge 2008 (VVR): 70). With reference to table 1, we note that on average approximately 30% of farms in our sample are affected by salinity and - consistent with the figure above - of that, approximately 6.8% are subject to moderate or greater salinity levels.

In this paper we use a surface salinity variable extracted from WADA's soil-landscape map unit database for South Western Australia (see section 3.4 below) to estimate the salinity levels affecting each property. Table 2 (adapted from Van Gool, Tille and Moore 2005 (VTM): 52) shows the surface salinity ratings measured by the electrical conductivity of a saturated soil extract in millisiemens per metre (ECe mS/m) that we use in this paper and the typical effect that this level of salinity has on crops. In the regressions below, the salinity variables indicate the proportion of each property affected by each level of salinity (i.e., each property can be effected by more than one level).

Table 2. Surface Salinity Rating

	Nil (N)	Slight (S)	Moderate (M)	High (H)	Extreme (E)
Approx. soil salinity range (ECe mS/m)	<200	200-400	400-800	800-1,600	>1,600
Effects on crops	Most agricultural crops not affected.	Very sensitive crops affected, e.g. lupins	Wheat affected, barley more tolerant. Cereals yield satisfactorily when seasonal conditions are favourable	Significant reductions in crop yields	Too saline for any crops

3.1b - Salinity Risk

The National Land and Water Resources Audit (2001) estimated that approximately 8.8 million hectares of land in Western Australia would be at high risk of developing salinity by 2050. This equates to approximately 30% of Western Australia's agricultural land (PE). At present, the rate of expansion is thought to be in the vicinity of 14,000 ha per annum (VTM). We use a simple weighted composite index for salinity risk in this paper derived from WADA's soil-landscape map unit database salinity hazard indicator. We use an index as opposed to the actual indicators because of concerns about the accuracy of the salinity hazard mapping (VTM). The index is weighted towards the high-risk indicator and gives an indication of the susceptibility of land to salinisation in the future.

3.2 Water

Plants require water both as a cooling mechanism, a transport medium for nutrients and as an input to photosynthesis. Transpiration, the mechanism used to obtain CO_2 for use in photosynthesis, is driven by the evaporation of water into the surrounding atmosphere via openings in the leaf called stomata. Loss of water causes a decrease in hydrostatic water pressure within the leaf and this pressure imbalance forces water (and nutrients contained in the soil) to be drawn up from the soil through the roots via osmosis (Wait 2007). When the stomata are open CO_2 enters. Hence the importance of an adequate source of water: if water is unavailable, transpiration must proceed at a relatively slower rate which in turn will limit the rate of photosynthesis (via a lack of CO_2 not necessarily water), the rate of nutrient uptake and the ability of the plant to remain cool. All these factors in turn will conspire to limit crop yield (Anderson & Garlinge (AG): 58).

An ideal measure of crop water use would be the amount of water transpired by the plant during the growing season. However, this is not easily measured let alone widely reported and hence we defer to precipitation as a proxy for the amount of water available for plants. Excessive rainfall has a detrimental effect on yield (e.g., waterlogging which inhibits oxygen uptake during germination (AG: 39) and rust disease which thrives in moist, humid conditions (AG: 204)) hence it is appropriate to model rainfall in level and quadratics, in anticipation of a concave relationship between yield and rainfall. Explanatory variables are therefore the 30 year average (1977-2006) of annual rainfall (mrain) measured in millimetres, and mrain squared (mrain2).

3.3 Temperature

Plant growth is driven by prevailing ambient temperature (Rawson & Macpherson 2000). In general, warmer weather implies faster growth and vice-versa. However, the general relationship alluded to above is ultimately driven at the biochemical level by enzyme reactions within the plant, where enzymes are responsible for controlling the rate at which chemical reactions (e.g., cell division and photosynthesis (the transformation of CO_2 and water into plant energy, biomass and oxygen using light energy)) take place (Miller 2000: 63, 91). The functional form that maps temperature to catalysis (the rate at which enzymes react) is generally non-linear and is approximately defined between threshold minimum and maximum temperatures. Beyond these threshold temperatures enzyme denaturation – a phenomenon that causes enzymes to slow and eventually stop reacting – occurs. In the case of irreversible denaturation, which occurs with increasing probability as temperature increases above the threshold point, the plant will die because all biological functions will cease (Abrol & Ingram 1996).

Thermal time is the amount of time that a plant is subjected to suitable growing temperatures across a given time span. A simple approximation to the exact thermal time can be found by constructing an index based on the average of the maximum and minimum temperature in any given day (known as 'degree days') so that the thermal time in a growing season indicates the amount of time that a plant has been subjected to suitable growing temperatures (Rawson & Macpherson 2000: Chapter 6). We model land value as a function of the mean temperature across the year. We do not include a quadratic term in mean temperature because the data range (between 15º and 21ºC - see Table 1) is well within plant optimal growth bounds. Explanatory variables are therefore the 30 year average (1977-2006) of average annual temperature (mtemp) measured in degrees Celsius.

3.4 Soil

The soil variables used in this study and discussed below are area weighted mean values per polygon . These are produced from WADA's soil-landscape map unit database for South Western Australia (the summary below is based on a comprehensive report by VTM). The database is compiled from detailed descriptions of zone land units, land characteristics, land qualities and land capability in the WADA's map unit database as of 2005. The data accounts for variability in scales (i.e. from 1:20,000 to 1:250,000) and combines the best published and unpublished survey information currently available, including descriptive information about map unit variability from land resource reports and laboratory information associated with soil samples collated in WADA's soil profile database (VTM: 1).

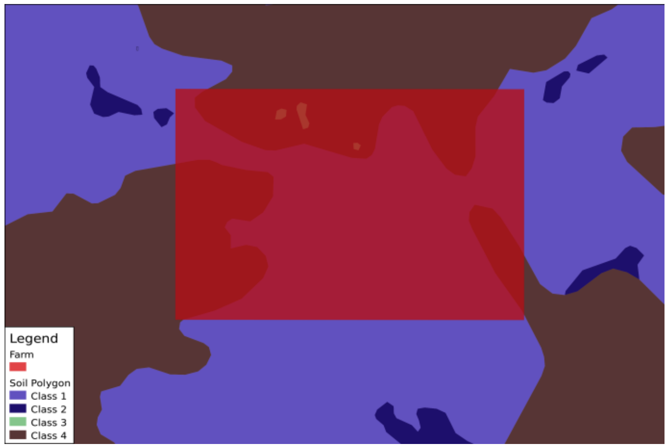

Figure 2. Overlay procedure for assigning soil to sales data

The WADA soil database contains more than 100,000 polygons. Each polygon contains information from one of approximately 5,000 unique soil map units. Each map unit is derived from within 32 soil-landscape zones that contain any where from 50 to 1,000 unique zone land units. The soil data was matched to sales data by a simple proportional overlay procedure. With reference to Figure 2, each farm was overlayed on the soil polygons and the relevant soil class was assigned as a function of the proportion of each polygon that fell within the farm.

In terms of accuracy, we note that the WADA database contains and is made up of a large number of disparate surveys and that the survey reliability is not uniformly high in terms of the reliability of the compiled information (VD see figure 1 p.4). As a result, we will not rely on the soil coefficients from the regression results other than as controls for the salinity variables.

3.4a - Clay (Cly)

The clay variable indicates the proportion of the soil that is clay. Clay content is a useful indicator of a number of soil attributes including water holding capacity, soil workability, compaction susceptibility, soil structure stability and susceptibility to wind and water erosion.

3.4b - pH

pH is a log measure of the acidity (less then 7) or alkalinity (greater than 7) of a soil. In terms of soil productivity, pH is an indicator of nutrient availability. pH extremes can result in nutrient deficiencies or toxicities that adversely affect plant production.

3.4c - Surface layer ogranic carbon (OC)

The OC variable measures the proportion of the soil that is OC. OC is used to determine soil quality characteristics including susceptibility to subsurface acidification and compaction, and susceptibility to surface soil structure decline and water erosion and repellence. Typically higher levels are advantageous with greater than 2% considered high so we would expect to see a positive coefficient on this variable.

3.4d - Coarse fragments (CF)

CF measures the proportion of coarse fragments, such as stones and gravel greater than 2mm in diameter in the surface layer of the soil. As the CF increases, by definition, the finer particles that provide plants with water and nutrients, decrease. Therefore, in terms of soil productivity, a high proportion of CF is disadvantageous as it inhibits soil water storage and rooting depth. We would expect to see a negative coefficient on this variable.

3.4e - Minimum Hydraulic Conductivity (Ksat)

Ksat measures the minimum hydraulic conductivity in mm/hour of the soil profile. Ksat gives an indication of soil permeability or the capacity of the soil to transmit water. This is an important indicator of soil quality as the water movement has implications for susceptibility to erosion, soil water storage and the movement of nutrients, salt and pollutants.

3.5 Other variables

It is important to control for variables which may in their own right affect property values, but which may be correlated with salinity. We include population density and the distance to primary roads. The various non-climate control variables are not of interest in their own right for this analysis, but their inclusion is intended to prevent the classic statistical problem of omitted variables bias.

4. Regression results

The dependent variable is the natural logarithm of inflation-adjusted sales price per hectare. Current salinity explanatory variables are extreme (salin_e), high (salin_h), medium (salin_h) and slight (salin_s) salinity. Predicted salinity is modeled by a composite index (sal_haz). Climatic explanatory variables are annual rainfall (mrain) and annual rainfall squared (mrain2) and average annual temperature (mtemp).

Year-specific constants are included to allow for time variability in market conditions. We include properties from the south-west agricultural region (see figure 1) of Western Australia. This is predominately cropping land, in particular wheat. All properties included are greater than 100 ha in area and used for dryland agriculture. We remove properties within 100km of Perth to control for option value associated with urban development and we remove any properties within 5km of the coast to control for the implicit amenity value. Regression results for the explanatory variables, with robust standard errors are reported in Table 3.

Table 3. Regression results explaining the log of agricultural land value per hectare for the south west agricultural region of Western Australia.

variable	coefficient	t-stat	p value
salin_e	-2.93	-4.95	0.00
salin_h	-1.02	-1.74	0.08
salin_m	-0.77	-2.83	0.01
salin_s	-0.37	-2.40	0.02
sal_haz	-0.02	-0.25	0.80
mtemp	0.15	4.51	0.00
mrain	0.013	6.66	0.00
mrain2	-0.00001	-5.26	0.00
pop_den	0.04	3.94	0.00
dist_proad	-0.01	-4.40	0.00
cf	-0.01	-2.63	0.01
oc	0.22	4.15	0.00
ph	0.16	1.54	0.13
cly	-0.03	-2.03	0.04
ksat	-0.01	-4.46	0.00
2004	0.10	1.79	0.07
2005	0.22	3.94	0.00
2006	0.15	2.32	0.02
2007	0.07	0.94	0.35
constant	-0.11	-0.09	0.93

5. Discussion

We find that the surface salinity variables are all statistically significant at the 5% level except the high salinity rating (p value of 8%), and all have the anticipated sign. We see that relative to no salinity, an increase in the proportion of the average property subjected to extreme salinity is highly deleterious to land values. Because we are using a semi-logarithmic model and we observe very large or non-marginal changes we correct the salinity coefficients using the appropriate adjustment in table 4 (see Halvorsen and Palmquist 1980).

With reference to table 4, holding other things constant we see that if a piece of land becomes salt effected, for example it becomes extremely saline, this results in as good as a total loss in land value on average compared to a piece of land with no salinity. If salinity levels occur at medium or high levels, we would expect per hectare land values to decrease on average by at least 50-60%. Finally, even a slight level of salinity will on average reduce per hectare land values by approximately 30%.

Table 4. Percentage Reduction in land values as land becomes salt effected

Salinity Level	% reduction
extreme	-94.7%
high[1]	-63.8%
medium	-53.9%
slight	-30.8%

These results are consistent with the outcomes presented in table 2. However, the result for 'slight' salinity is quite high given that only sensitive crops are expected to be affected. There may be a buyer expectation that slightly affected land will get worse and, therefore, the land is discounted accordingly. This is consistent with the estimate above suggesting that the amount of land affected by salinity is likely to expand. Given this, it is somewhat surprising that the salinity hazard variable was neither statistically or practically significant (although it does have the correct sign). It may be that buyers concern with current salinity levels is swamping this signal or that, as suggested above, future estimates are uncertain or of insufficient quality.

Briefly, we note that the climate control variables all have the correct sign and are highly statistically significant. Higher temperatures and rainfall on average increase per hectare land values. Being closer to main roads and higher population densities is advantageous. We note that the two soil variables that were apriori predictable (organic carbon (oc) and coarse fragments (cf)) have the correct sign and are highly statistically significant.

[1] Statistically significant at 8%.

6. What can we use the estimates for?

An indicative use for the estimates produced above are as an indication of the avoided cost of managing the spread of salinity and of how the market is factoring in or pricing salinity risk. Taken literally, the estimates suggest that if we can avoid salinisation of salt free cropping land holding other factors constant, we can avoid a reduction in land values of anywhere between 30% and 95%. In terms of dollar values and relative to the average land value per ha in this study of approximately $1500, that amounts to savings of between $450 and $1425 per hectare. If we convert the average land value into an annual profit estimate using a discount rate of 5% across an infinite time horizon this equates to an annualized avoided loss in profit of between $22.5 and $71.25 per ha on per ha annual profit of $75 (see table 5 for alternative discount rate scenarios).

Table 5. Estimated reduction in annual per ha profits given a certain discount rate on an average land value of $1500/ha[2]

Discount rate	Annualised Profit	Salinity level	
-	$/ha/yr	Slight	Extreme
3%	45	13.5	42.8
4%	60	18.0	57.0
5%	75 (98)	22.5 (29.4)	71.3 (93.1)
6%	90	27.0	85.5
7%	105	31.5	99.8
8%	120	36.0	114.0
9%	135	40.5	128.3
10%	150	45.0	142.5

7. Comparisons to contemporary studies

The estimates above provide an upper bound estimate[3] of the quantum of costs in terms of appraising investments to combat secondary land salinisation. A number of other studies provide alternatives to valuing salinity impacts. These include a gross benefits methodology (Kingwell et al 2003 (KEA)), an audit methodology and a land valuation methodology (all three are summarized in Sparks et al 2006 (SEA)).

The gross benefits methodology produces profit estimates using gross benefits and costs from various south-west WA farming regions by implementing alternative crop management. For example, introducing salt tolerant crops such as lucerne as

[2] The highlighted row indicates value calculated over a 30 year time horizon and is referred to for comparison purposes in the text on the following page.

[3] They are likely an upper bound because we do not specifically control for government support and taxes that will likely be factored into these estimates.

part of the cropping cycle. This is a production function or simulation technique and in their study KEA estimate that on average, implementing alternative techniques will realise an annual estimated profit of anywhere from $1 to $12/ha compared to standard cropping rotations. In their study, SEA appear to claim that this is a proxy for the avoided cost of salinity under the assumption that alternative crops can costlessly fix dryland salinity. This assumption is somewhat implausible given that, for example, lucerne is neither a perfect substitute for grain crops (presumably if it was at least as profitable, farmers would be using it at present) or, as a perennial crop, a viable solution to dryland salinity (see Pannell and Ewing).

It is not completely clear for which year the estimated profit figures are current or what the mean farm profit in the study was so it is difficult to make definitive comparisons to our estimates. However, with this caveat mind, if we assume 2003 (the date of publication) dollars we can inflate this figure to 2008 dollars and we get an estimated per ha profit of about $1.16 to $13.94/ha. If we then compare this figure to our estimate we can surmise that even on slightly saline land using a highly conservative discount rate (see Table 5), the implied salinity effect is extremely small. Alternatively, if we believe that the estimates in this paper are correct, we can say that alternative cropping techniques will struggle as a viable adaptation technique to mitigate shrinking land values.

The audit and land valuation methodology are closer methodologically to the hedonic approach in that they rely on market data. But they use an arbitrary 50% reduction on estimated land values as a proxy for the actual reduction in land value caused by salinity. The audit methodology uses reported operating profits from a survey of approximately 500 farmers in the WA wheat and sheep belt while the land valuation methodology uses sales data from WA for 2001 to produce annualized figures for profit using a 5% discount rate across a 30 year period (see highlighted row and bracketed figures in Table 5 for comparison). In comparison to the estimates produced for this paper, the assumed 50% reduction accruing to salinity will be relatively accurate for projecting lost value in areas suffering medium to high salinity ratings but will substantially undervalue the effect in areas subject to extreme salinity.

8. Conclusion

We find that, ceteris paribus, the impact of salinity on per ha agricultural land values in the SWAR ranges from approximately a 30% reduction under slight salinity up to a 95% reduction when salinity reaches extreme levels. As discussed above, we believe that the hedonic approach offers a more robust and reliable technique for estimating the damage caused by salinity. Compared to the alternatives, we use a relatively flexible approach to modeling farm level outcomes. Instead of arbitrary damage estimates, we rely on a large sample of market data based on 5 years of sales and we carefully and appropriately control for covariates to produce robust estimates of the effect of salinity on prevailing agricultural land values.

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Appendix 1. Land value predictions under hypothetical salinity scenarios

We want to investigate the impact of an increase in the level of salinity across the SWAR. We do we this in the following way. We construct a grid across the SWAR with grid spacing at approximately 1km intervals and we assign the same variables to each grid point as per the regression presented in this study and using the same techniques described above. This produces approximately 170,000 grid points within the SWAR. We then calculate a baseline scenario that reflects prevailing or current conditions and we run a number of counterfactual scenarios to assess the impact of changing salinity levels holding other variables constant.

We then apply the following four steps. First, calculate the regression prediction for the baseline scenario. That is, combine the estimated regression coefficients with the explanatory variables corresponding to the baseline. Second, calculate the regression prediction for the particular scenario of interest. Third, subtract the baseline prediction from the scenario of interest prediction. This is the predicted difference in the logarithm of the dependent variable. Fourth, take the exponent of that predicted difference. This final calculation is the predicted percentage change from the baseline to the scenario of interest. Because this calculation involves the subtraction in step 3, any terms that do not differ between the scenarios have no impact on the percent changes estimate.

Because we are running a semi-log specification, rather than 'backing out' a baseline landvalue we use the averages from the regression as the point of comparison. The area of our study within the SWAR is approximately 17.5 million ha and the mean value per hectare is approximately $1500 per ha[4]. Multiplied together this gives us an indicative total value at current salinity levels of about $26 billion.

We look at 3 scenarios. The first predicts what might happen if those grid points that currently have no salinity problems but have a risk of developing salinity as per our salinity risk data were reclassified with salinity. This represents about 8% of the total grid points within our study area. With reference to table A1, we can see that by increasing the salinity levels from none so that they take on the same

[4] An agreed estimate of the total value of agricultural land in the SWAR is difficult to come by. We note that the estimate produced above is comparable to those presented by Kingwell and Pannell (2009) but potentially much higher than those presented by ABARE (2010) that charts returns to broadacre farms generally.

average salinity levels as the rest of the sample results in a reduction in total value per hectare of 1.13%. In terms of the total value of agricultural land in the survey area, this represents a loss of approximately $295 million.

Table A1 Salinity scenarios - baseline value of study area is $26 billion.

% change in avg. per ha land values	Lost value (millions)
S1 - Salinisation on high risk land as per rest of sample	
-1.13%	-$294.91
S2. Highly saline land becomes extreme holding others constant	
-3.11%	-$809.52
S3. All classes one rating worse plus 25% of remaining saline land becomes slight	
-22.01%	-$5,722.49

Scenario 2 looks at what might happen if the amount of land currently classified as high salinity became extreme holding all the other classes constant. This would result in a two-fold increase in the average area classified as extreme per ha and reduce total agricultural land value within the study area by approximately $800 million.

Scenario 3 assigns each grid point the next worse salinity rating. That is, where the current rating is slight, the new rating is medium and so on. 25% of the remaining land is assigned a slight salinity rating. As per table A1 this results in a dramatic loss in agricultural value of approximately $5.7 billion reflecting a 22% drop in average land values per hectare against the baseline scenario.