The Red Warning Light is On

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How the Onion Weed was saving Moorunde and the Twelve Mile Plain Wildlife Reserve from becoming a series of saltpans, and why that is no longer the case.

"She only wants to give her skills" – At Their Mercy, Four Corners, ABC TV

The Macquarie Dictionary defines Agronomy as – "the applied aspects of both soil science and the several plant sciences". However when I studied the subject at Roseworthy Agricultural College we also had several lectures on the climate and weather, and even a number of exam questions on climate and weather as well. Given that Moorunde and the Twelve Mile Plain are in a semi-arid climate area that is notorious for its vagaries in weather conditions, I prefer to include these aspects as well. Obviously (as a retired farmer) I know agronomy is an important factor in agriculture; however over the past fifty years of involvement in Conservation and Natural History, I have also learnt that it is equally important in forming management concepts and decisions for Wildlife Conservation Reserves. In fact those who have a working knowledge of agronomy hold an invaluable tool that "separates the sheep from the goats", as opposed to those who don't!

Almost nobody really likes weeds, but there is a distinct difference between managing a backyard garden, a farm and a Wildlife Conservation Reserve. For farm pasture used for grazing livestock, and for what is essentially pasture for wildlife (such as wombats) on Conservation Reserves, the reality is that weeds (which are firmly established) serve important purposes – especially in semi-arid areas.

It no longer matters how the weeds originally came to be on places like Moorunde (and neighbouring Brookfield Conservation Park). What we *do* about them is important. Rather than the fact that they did arrive and that we didn't or couldn't stop them spreading, what is more important is to know why they spread and what that is telling us – because in some instances their current presence can give us information; and although they are seen as undesirable, their presence may well be preferable to the consequences of their removal or absence.

For Moorunde and similar areas in the Murraylands, certain weeds, and more specifically their growth vigour and relative abundance in certain locations, are indicators of the health of the land. This information does not just apply to the food pastures for only wombats, but to the welfare of almost half or two thirds of vegetation habitat of Moorunde Wildlife Reserve. And the information is worrying.

Why? Because now, in many parts and over significantly large areas of the Twelve Mile Plain, even the weeds are struggling to grow. And the original 2,000-hectare area of Moorunde is only a few stages behind. So what is happening?

Any agronomist in Australia will tell you that if you leave an area of soil bare or significantly bare of plants for long enough it will become badly affected by rising salt. They will also tell you that should a bare area also be hard panned by either excessive or poorly timed cultivation, then the effect of salt rising to the surface soil will be enhanced and accelerated – to the point where not

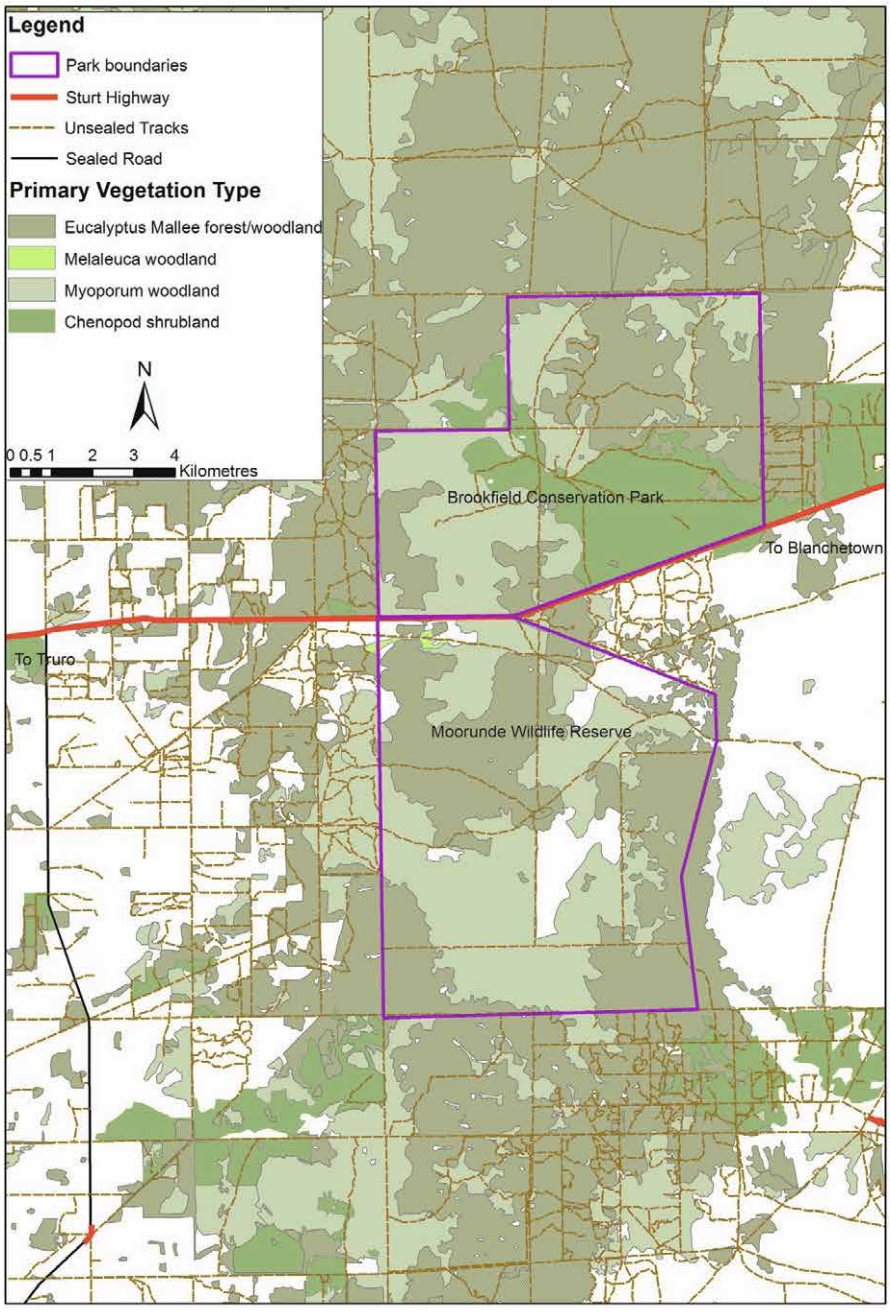

Figure 1: *Map of Moorunde Wildlife Reserve (including the Twelve Mile Plain) and Brookfield Conservation Park. The "endangered" areas of soil within Moorunde are the white regions.*

even the weeds can grow!

On Moorunde, excessive and poorly timed cultivation has been and is being done by the wombats in their search for the bulb of a weed to sustain themselves – the weed known as Thread Iris (*Moraea setifolia*). Thousands of hectares of land are being laid bare and hard panned; and therefore prone to salt rising into the root zone of native pasture plants that are no longer there. In many areas, all that is standing between soil that is still potentially suitable for re-establishing native pasture and soil being scalded by salt is another weed, Onion Weed (*Asphodelus fistulosus*).

Included in this discussion paper are a series of photographs and diagrams that I am hoping will illustrate to you the process that is currently occurring on Moorunde and Twelve Mile Plain. I am also hoping they will, accompanied by this explanation, convince readers to realise the urgency and that the time to act is now.

There are, and have been, no sheep and virtually no rabbits on the Reserve since 2008. While the wombat population has to date remained static, but with their health in decline [Lethbridge, Wells and Taylor, unpublished Data]. However the last occasion when the native grasses were seen to be in reasonable abundance was over the years of 1983 to 1985 [Clements and Taylor, unpublished data]. At the time, the Society's Management Fellowship believed that this was because of an above average rainfall year in 1983. That is not correct. It was due to the severe drought in 1982, when the rabbit population was decimated and it then took a number of years for their numbers to recover (Coman 2009 describes this type of pattern). Any year of average rainfall will bring about Spear Grass germination and growth providing that the first rains occur in early autumn. Both Moorunde and the Twelve Mile Plain experienced this abundant growth of grass [Taylor, unpublished data].

There is clear evidence that the native grass pastures went into rapid decline after 1985, due to rabbits, because sufficiently high rainfall events to grow native grasses have frequently occurred since then. This is supported by observations from the surrounding district on land that still runs sheep, and from enclosures that have been erected on Moorunde. Yet the wombats still manage to survive? This is because an exotic weed *Carrichtera annua*, commonly known as Wards Weed, had invaded the region in the 1970's. Its presence has prevented the wombats on the Reserve from starving. Without this partly palatable weed, there would have been no wombats on Moorunde since the last of the grass was eaten off in 1985. It must be accepted that the minimum intervention management policies (still currently being implemented on the Reserve) have had no advantageous influence on the survival of these animals.

The current management policy of attempting to control selective weeds (but not Wards Weed) and otherwise "leaving nature to take its course" is having a negative impact on the wombats' chances of survival. On significantly large areas of the Reserve the Wards Weed has also been eaten out by a relatively recent and unprecedented increase in Kangaroo numbers. The kangaroo impact has actually "dwarfed" the past impact of both sheep and rabbits combined. The increased kangaroo population has also been documented on neighbouring Brookfield Conservation Park [Lethbridge and Wells, unpublished data]. Casual observations and anecdotal reports support this situation across the entire Murraylands Region.

However! Fortunately from the point of view of saving the soil from permanent damage by rising salinity, these areas have (until now) been saved from becoming left as bare ground by the kangaroos, due to the invasion of a weed that is not palatable to kangaroos, wombats, rabbits or sheep – Onion Weed! Had Onion Weed been an edible plant, the ground would have been laid bare in some areas now for several years. This is where we pick up our pictorial story – as now even the Onion Weed is struggling to grow and is becoming thinned out. This is due to a unique and unprecedented combination of circumstances occurring between wombats and another weed. A weed that paradoxically, has also temporarily prevented the wombats from starving as the Wards Weed disappears – Thread Iris!

The irony is if native Spear Grass (the pasture we wish to restore) were not so palatable and nutritious, *it* would be a much worse and far more notorious weed than any of the others.

In figure 1, a map of Moorunde and Brookfield, the "endangered" areas of soil are those coloured white on the map (but not annotated in the legend at the top left hand corner). These were once open native grasslands areas that are now "weed lands". These are the areas that once carried the highest density population of wombats in the entire Murraylands Region; and most of it is (to the right in the map) outside Moorunde and Brookfield. The areas depicted in the legend as Myoporum Woodland (pale green) are also vulnerable to rising salinity levels and some of these vegetation communities are endangered.

Figures 2, 3, 4 and 5 illustrate how moisture in the soil (moisture that contains dissolved salts) rises to the surface by a process, known as Capillary Action in science laboratories and as Capillary Rise in Soils and Subsoils by agronomists. Figure 5 shows how

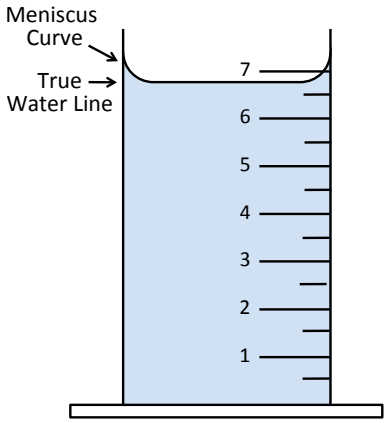

***Figure 2**: Diagrammatic rain gauge illustrating the meniscus curve caused by the "surface tension" of the water.*

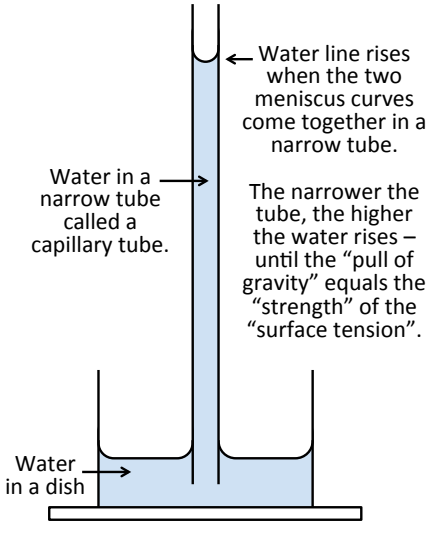

***Figure 3**: Diagrammatic capillary tube illustrating capillary action.*

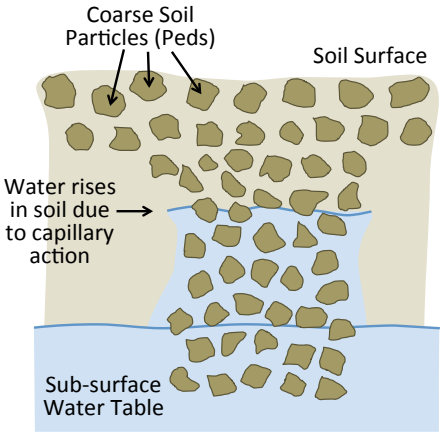

***Figure 4**: In coarse soil (comprised of large particles or peds) capillary action occurs, but to a limited height, since the voids between the peds are also large.*

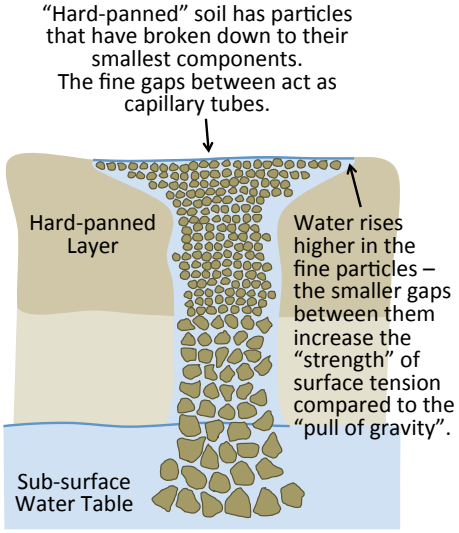

***Figure 5**: There are two forces acting on soil moisture: (1) Gravity, which causes drainage or downward soakage into deeper soil and (2) Capillary Rise, which can bring subsoil water to the surface where it evaporates, leaving behind any dissolved salts.*

capillary rise becomes more pronounced as the soil particles become smaller and closer together – either due to being a clay soil or from being 'pounded' into a hardpan.

Anybody who has mopped spilt water with a sponge has experienced capillary action. If you place two sponges in a tray of shallow colour dyed water, one sponge open and the other fine, you will see the water rise higher in the fine sponge – as it does in the diagrammatic soil in figure 5. However the open sponge takes in the water more rapidly and this is an important principle if our 'sponges' are soils. The ground surface of almost any field has some undulation and the soil on the higher areas contains less of the smaller particles that make up clay, than that found in the lower ground.

This means in effect, the soil on higher ground acts more like the open sponge and soaks up rain water more rapidly, while the lower ground has a more pronounced capillary rise with whatever subsoil moisture is already there, which always contains dissolved salts.

Meanwhile the sub-soil roughly follows or duplicates the undulations of the surface. But the particle size (and hence the gaps between the particles) tends to remain uniform across the range of undulations. This means that the subsoil moisture level also tends to undulate with the surface – until other forces come to play. When rain falls, the higher ground takes in the rain more readily, with water tending to lie longer on the surface or just below the surface in the lower areas. This causes a "lens effect" of water in the ground. The subsoil also follows the contours of the undulations, and the lower level clay can hold more water (like a finer sponge) per unit of soil volume. This produces higher hydraulic pressure on the layer of sub-soil saltwater held in the high ground, as water tends to find its own level – see figure 6. In effect this salt water is "pressed" and forced to move laterally towards the lower ground; where it ultimately comes to the surface (see figure 7), as the different concentrations in the water salinity tend not to mix. That is, the fresher rainwater doesn't mix with the lower saltier water already in the sub-soil and this saltier water is 'pushed' side-ways and comes to the surface in the sides of the lower slopes.

(I have been criticised at times for not writing articles 'scientifically enough', but I would rather provide a straightforward explanation as a "science interpreter".)

In figure 8 the sub-surface fresh water layer is significantly depleted by plant root extraction, and so the excess soil moisture is not great enough to apply sufficient hydraulic pressure on the sub-soil salt water table to either press the salt water laterally or raise the water table high enough in the depressed area to enable capillary rise of salt water to the surface.

Consequently soil with a significantly diminished plant cover has its moisture moving in different directions to that of soil with a good healthy growth of grass or even Onion Weed if grass is absent due to being eaten out and this altered direction of movement ultimately causes salinity to rise to the surface. Then, in addition to that, if some event has caused the soil to become damaged and its particles even further reduced in size (as in the case of hard panning) the salinity rise is enhanced and accelerated.

I have already discussed the fact that the take-over by Onion Weed has been caused by all of the palatable and edible plants being removed by excessive grazing, creating a situation where the Onion Weed no longer has to compete with anything else. The Onion Weed would still have arrived and would still be there but its complete take-over is simply because everything else has been removed – as the weed is in fact a poor competitor. Now, though, even the Onion Weed is rapidly thinning out. What then is causing this? As it is not being eaten.

The presence of Thread Iris is not in and of itself affecting the Onion Weed. The two plants can happily co-exist as they extract moisture at different levels in the soil. Unlike Onion Weed, Thread Iris has a bulb, or more accurately a corm. Onion Weed does not have a bulb as such, but a thickened, moisture retentive sub-surface stem. So that over a dry summer

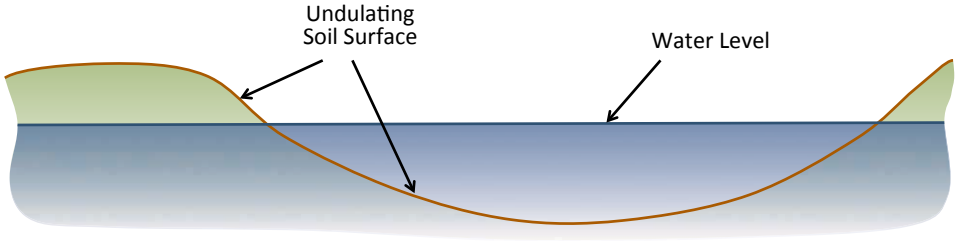

***Figure 6**: This is a "representation" of what water always tries to do – become level!*

However, this tendency produces hydraulic pressure on moisture that has soaked into the soil. That pressure forces the salt-laden moisture already in the soil to move laterally towards the lower ground as shown in figure 7 below. This works in conjunction with the capillary rise between soil particles, illustrated earlier.

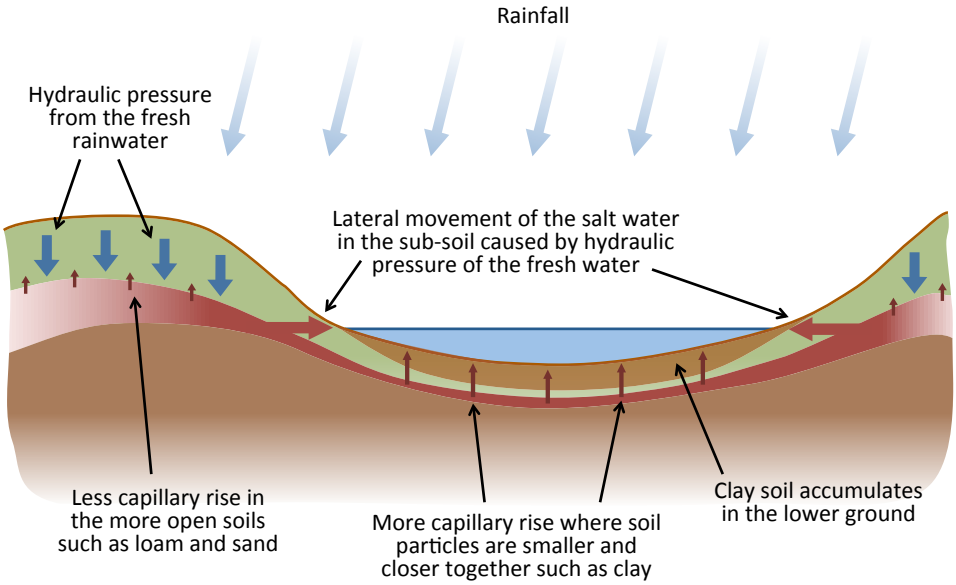

***Figure 7**: Clay soil consisting of small fine particles accumulates in the lower ground. Here the salt-laden sub-soil moisture is brought to the surface and mixes with the slower soaking fresh rainwater where It evaporates, leaving behind the salt.*

it stays alive, even if the top dies off. However when there is summer rain, as has been happening more frequently over the past 27 years, the plant top quickly regrows. This gives the weed a head start over annual plants such as Wards Weed, that have to germinate from seed each year. It means that Onion Weed, like Spear Grass that is also a perennial herbaceous plant, takes up more of the total soil moisture than annuals; and therefore assists in reducing (eliminating if dense enough) the capillary rise of salt laden moisture coming to the surface.

Figure 9 is a photograph of what the Onion Weed was like on clay soils after the summer rains of 2010-2011, with dense lush growth. Figure 10 shows how widespread the weed is over an area of Myoporum Woodland on the Twelve Mile Plain. This photograph was taken in January 2011. The copper coloured plant tops are the ripening seed stems, while the base of the plants are still lush and green. This lush green foliage extracted soil moisture from the summer rain that fell in December 2010 (around 150mm in one heavy cloud burst!), helping to keep the subsurface saline water level low.

Figure 11 is an illustration of Onion Weed on a clay area, which was formerly grassland, during the following summer that had little rain. The weed has died back to its dormant stage, waiting for the next rain. With no grass or even Wards Weed the wombats have started to dig through the soil amongst the Onion Weed searching for Thread Iris corms to eat. Insufficient follow-up rain fell over the summer of 2012-2013 to keep the weed green. Figure 12 shows the plants in March 2013. While still alive they have died back to just their moisture-retentive sub-surface stem. The wombats have become more desperate for Thread Iris corms and the entire area within Figure 12, from the foreground to the horizon has been so extensively dug over that many Onion Weed plants have been excavated.

This summertime digging by wombats of the dry soil stimulates dormant Onion Weed seeds to germinate. With each mature plant yielding between 1,000 to 2,000 seeds and each seed having a variable dormancy period ranging from one to five or more years, the idea of trying to eradicate this weed by spraying it is, to put it bluntly, simply ludicrous! It would also be absolutely irrational and destructive to attempt to do so, for if it was actually possible to quickly eradicate, the soil would be left completely bare and exposed with nothing growing in it to keep the moisture from rising and bringing up salt with it.

Now to another location, where the progression of soil degradation is a few steps behind that of Figure 12. For a few years, even with wombats "cultivating" the soil, dormant Onion Weed seeds do germinate and re-cover the ground with

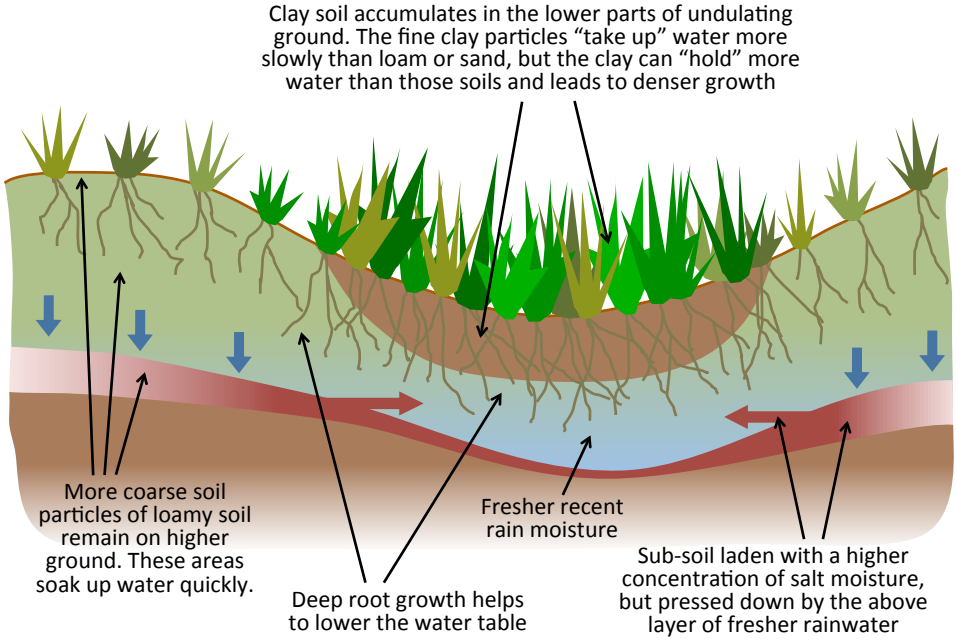

***Figure 8**: Although the denser "sponge" of clay soil is slower to "take up" water there are many more tiny gaps between the fine particles compared with loam or sand. This enables the clay to "hold" more water, which leads to higher, denser and more robust vegetation on the clay.*

The larger particles of loam or sand remain on higher ground. These areas soak up rainwater more rapidly. The sub-soil particles are generally an even size. Capillary rise within the sub-soil is therefore roughly the same in all areas (regardless of the surface soil) so that the subsurface water table roughly follows the undulating surface.

Deep root growth from a good ground cover of plants lowers the water table. This prevents capillary rise from bringing salt-laden moisture to the surface.

Figure 9: *Dense lush growth of Onion Weed on clay soils following the heavy summer rains of 2010-2011.*

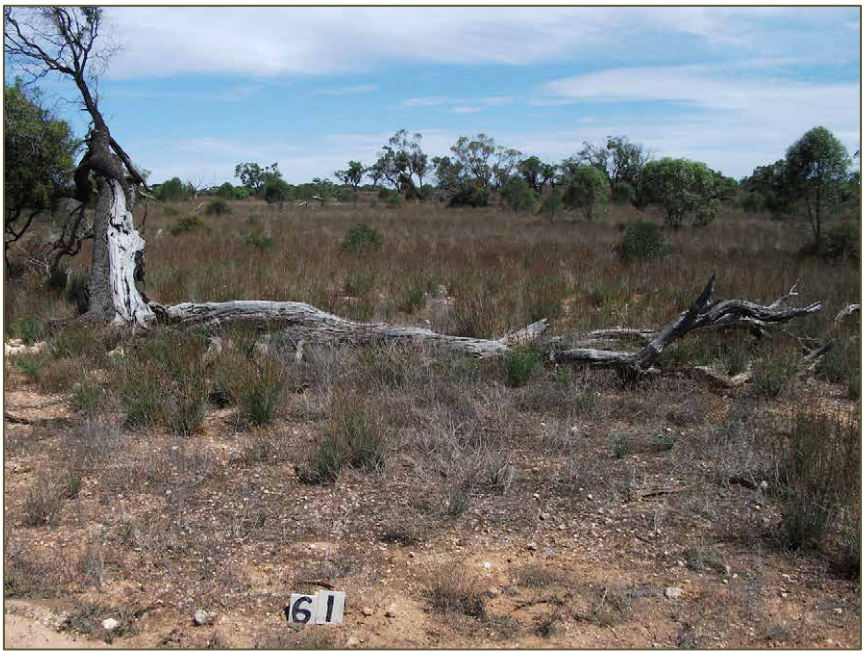

Figure 10: *January 2011. Widespread Onion Weed over an area of Myoporum Woodland on the Twelve Mile Plain. The copper coloured plant tops are the ripening seed stems, while the base of the plants are still lush and green. This lush green foliage extracted soil moisture from the summer rain that fell in December 2010 (around 150mm in one heavy cloud burst!), helping to keep the subsurface saline water level low.*

Figure 11: *January 2012. In contrast to figure 10, this photo shows Onion Weed on a clay area following a dry summer. The weed has died back to its dormant stage, waiting for the next rain. With no grass or even Wards Weed the wombats have started to dig through the soil amongst the Onion Weed searching for Thread Iris corms to eat.*

Figure 12: *March 2013. Following another dry summer, the Onion Weed plants have died back to just their moisture-retentive sub-surface stems. The wombats have become more desperate for Thread Iris corms and this entire area, from the foreground to the horizon has been so extensively dug over that many Onion Weed plants have been excavated.*

Figure 13: *Fresh growth of Onion Weed following summer rain in January 2015. Amongst the green growth can be seen the dead stems of excavated plants from the previous summer. This is step one in the process to salinity. The dead excavated plants will soon expose bare ground.*

Figure 14: *The next stage in the progression to eventual "salt panning". The dead stems and leaves from previous years of excavations have been "trashed and mashed" and the ground between the newly germinated plants is laid bare by May of 2015.*

at least a “protective” layer of vegetation. Figure 13 shows any area of fresh growth of Onion Weed after summer rain in January 2015. Amongst the fresh growth can be seen the dead stems of excavated plants from the previous summer. This is step one in the process to salinity.

Step two is illustrated in Figure 14; the next stage in the progression to eventual “salt panning”. The dead stems and leaves from previous years of excavations have been ‘trashed and mashed’ and the ground between the newly revived plants, from the rain in January 2015, is laid bare by May of 2015. The entire area of ground shown in Figure 15 is a nearby location, illustrating step three in the decline of the soil. The whole area has been repeatedly dug over but only a small fraction of the excavation is recent. In fact most of the ground has been re-covered by mosses and lichens, known as duricrust. The soil has been repeatedly dug up, over a number of years during summers when the ground is dry, thus destroying the soil structure. Essentially, the soil has been pulverised down to its finest individual particles and subsequent rains “cements” the particles together into a solid block – rather like mud bricks, except this is a continuous sheet called a “hardpan” with a thickness of about 10-15cm. Ironically, while this hardpan tends to prevent rainwater from penetrating down into the soil, as illustrated in Figure 16, it actually increases capillary rise and evaporation of subsurface moisture, which brings salt to the surface.

Figure 15: *Step three in the decline of the soil. The whole area has been repeatedly dug over but only a small fraction of the excavation is recent.*

Figure 16: *Rainwater pooling in pits of hard panned soil. Ironically, while rainwater is unable to penetrate the surface, capillary rise is enhanced.*

So it’s a “double-edged sword”. Figure 16 shows water lying about in puddles, evaporating after rain, leaving behind the 60 parts per million of salt, that comes in rain water, adding to the salt already present in the soil moisture. As illustrated in Figures 5 and 7, soil with finer particles (such as hard panned soil) draws more moisture, laden with dissolved salts, to the surface via enhanced capillary rise.

Over time, this salt becomes so concentrated on the surface that it “burns off” any plants that may germinate and eventually leads to all of the depressed ground becoming a saltpan. This is Step Four. Once established saltpans expand and eventually envelop the higher soil of the undulating surface. This is Step Five and is illustrated in Figures 17 and 18, photos taken on a property near Moorunde, where the hot dry winds in summer blow the bare salt-concentrated soil onto the higher ground. This is a serious and insidious process that is now just starting on Moorunde and the Twelve Mile Plain.

Figure 19 is a photograph taken on the 25th March 2015 of the same area as earlier shown in Figure 12. It follows a significant rainfall event in mid January 2015 when approximately 70mm of rain fell in one week. By then the Onion Weed should have looked like that shown in Figure 9 after similar rainfall events. As explained earlier, the weed isn’t as thick, due to the persistent desperate digging and excavation by wombats. Despite this, the individual Onion Weed plants that are present should be much higher and more robust than they are – as there is significantly less competition between the plants. But they are not. A closer inspection of the ground reveals that none of it has been dug over by wombats during the summer of 2014-2015. In fact some soil has re-formed a duricrust of mosses and lichens on the surface. The last time any of this soil was turned over by the wombats was during the summer

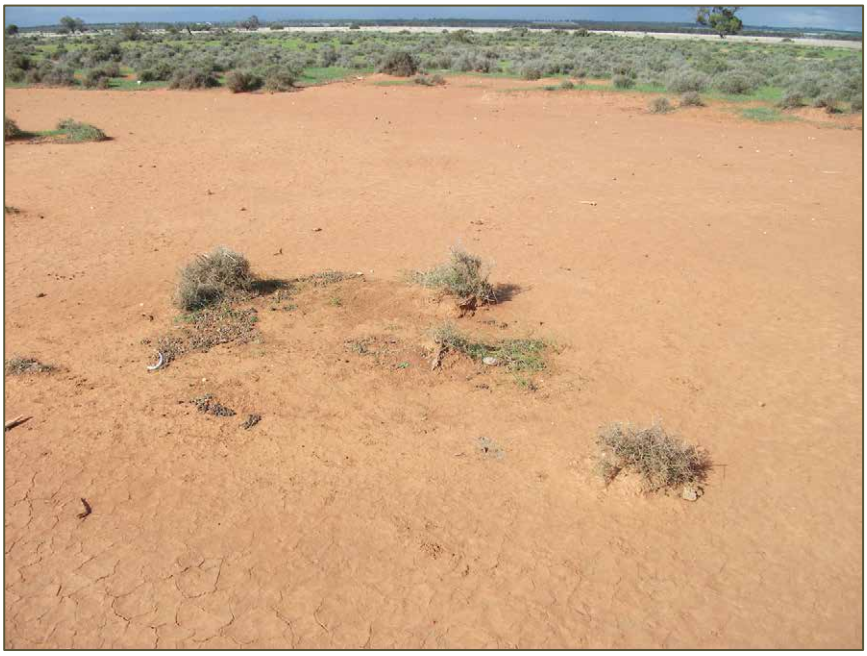

Figure 17: *Step Five! An expanding saltpan located on a property located a short distance to the west of Moorunde and the Twelve Mile Plain.*

Figure 18: *Another view of the saltpan near Moorunde and the Twelve Mile Plain. High levels of surface salinity "burn off" any plants that may germinate. The only vegetation growth is in the car tracks – where fresh rainwater collects.*

of 2013-2014 and by May 2014 (see Figure 20) the weed has grown but is still in a somewhat stunted and sparse state – despite unusually good rain in summer and excellent above average rain in autumn. In fact the green between the tussocks of Onion Weed is Thread Iris weed. Very little of the soil was disturbed by wombats despite an obvious abundance of Thread Iris still present. We need to examine why.

In the centre of the photo Figure 20 is a steel dropper. Immediately to the left of the dropper a Wild Sage plant (*Salvia verbenaca*), another weed. If you examine Figure 19 carefully you will see a few of these Wild Sage plants scattered about too (there is one at the bottom right). In some clay pans, Wild Sage is still the dominant weed, with Onion Weed still absent. Wild Sage is also an unpalatable plant to herbivores and grows with a deep taproot. Employing a pick or long crowbar one can extract these plants from the ground with their taproot till attached. In hard panned soil a pick or crowbar is necessary to achieve this! Figure 21 shows a sample of Wild Sage plants that were dug up in this way. Notice that all of the taproots are bent, some at 90 degrees. The soil has become so hard that the plants have been unable to send down a straight taproot!

Figure 20 shows Thread Iris is still in abundance for wombats to excavate the corms. However, as the mature corms are from 10cm to 15cm deep in the soil, it takes a long time for rain water to soak down to that depth, before they can reshoot. This means that regeneration of even this sturdy plant is noticeably delayed on the hard panned areas. Hence the initial absence of Thread Iris tops in these areas is not, as some have proposed, the reason for the near absence of wombat surface soil excavation.

Studies by scientists, including examination of blood samples of live animals on the neighbouring Brookfield Conservation Park indicate that although the wombat population is still static, their health and physical condition has deteriorated on the poor diet of Wards Weed and Thread Iris tops and bulbs. [Lethbridge and Wells, unpublished data]. The last study of the population on Moorunde also show the population has experienced no appreciable decline [Taylor, unpublished data]. However, animals are now being found in a dull and moribund state (blind, deaf, weak and emaciated). When walking about Moorunde, one now comes across many warrens where blowflies and the stench of decaying flesh emanating from a burrow entrance give away the death of an animal underground.

My own theory for the fact that areas that were once extensively dug over, but are now no longer being dug over is the combination of substantially less wombats in these specific areas, combined with their weakening physical condition. The hard panned surface is likely preventing even these "bulldozers of the bush" from effectively digging through the hardened topsoil layer. No doubt healthy wombats could do this, but for sick animals, the energy expended in digging versus the energy gained from eating the toxic Thread Iris corms is a losing battle. Since this is still an unproven theory, and only a hypothesis, I am open to alternative ideas and suggestions about this situation. Regardless of the specific cause, this is a matter of serious concern, not only for the survival of the wombats, but also for the entire habitat community of the

Reserve. Especially since the wombats are forever expanding the dug over and therefore degraded areas of soil.

In May 2014, I commenced a small trial on 0.16 hectares on the clay-pan depicted in Figure 20. Using some miniature equipment that I made up from scrap metal, I "opened up" the hard panned topsoil. The first piece of equipment was towed behind my 4WD Ute. Subsequently I used my quad-cycle as a mini-tractor to pull the equipment. The main aim was to illustrate that Onion Weed can be sufficiently suppressed by "soil disturbance" which induces their dormant seeds to germinate – a practice that is commonly known to work. The newly germinated plants are then destroyed with follow up cultivation and/or spraying. The area is then reseeded with native Spear Grass and sections of the area fenced off from any herbivores, to remove immediate grazing pressure.

Figure 22 is a photograph taken on 28th April 2015; about 12 months after commencing the trial and immediately after half (0.08 hectares) of the original 0.16 hectares received its final cultivation to kill the Onion Weed that had germinated from the initial soil disturbance stimulation in 2014. The remaining half of the trial area is on the far side of the freshly cultivated soil and has a green tinge to it, which is newly germinated weeds – Onion Weed and Wild Sage. Half of this green tinge area was sprayed with an appropriate herbicide on 17th May 2015, while the remainder, situated between the cultivated section and the sprayed area, was last cultivated in August 2014. The entire 0.16 hectares was seeded (using my custom blower device) with Spear Grass at a rate of 2kg/hectare, on 16 May 2015. I plan to erect protective weld-mesh fencing over sample areas on each of the three separately treated sections.

Unfortunately, due to the basic and not quite fully effective homemade equipment that I had available, more cultivations than desirable or optimal had to be done to penetrate the hard ground. To my great disappointment, this resulted in the soil becoming somewhat hard panned again, which will likely affect the trial result. In future, if appropriate commercial grade equipment is available, this situation will be avoided. Despite this, the Spear Grass is not expected to germinate until next year (2016) due to seed dormancy, and then, only if we have sufficient rainfall at the right time in or by April (or perhaps early May at the latest).

Figure 19: *March 2015. Taken at the same location as Figure 12, but following a significant rainfall event – approximately 70mm of rain fell in one week in January 2015. After such an event, the Onion Weed should look like that in Figure 9.*

Figure 20: *May 2014. Despite unusually good summer and autumn rain, the Onion Weed is still quite stunted and sparse. Between the tussocks of Onion Weed is an abundance of Thread Iris that has not been excavated by the wombats. Why?*

This expected dormancy period means that the ground will have been laid bare (following mechanical cultivation) since May 2014 to April-June 2016 or longer if 2016 doesn't produce sufficient rain at the right time – that is a minimum of two years. Hence there is going to be a contest of salinity damage between the softened coarse soil of the cultivated area and the fine hard panned (and sparsely vegetated with Onion Weed) areas surrounding it. Should the cultivated soil prove to be worse in terms of salinity results, then it will indicate possible ways ahead, (1) the current condition of the soil in this clay pan is worse than I anticipated at the start of the trial in 2014 and a whole new approach is required, or (2) another option is to "break the hardpan" but leave the existing Onion Weed plus its stimulated dormant seed growth to

Figure 21: *A sample of Wild Sage plants dug up from hard panned soil using a long crowbar. All of the taproots are bent, some at 90 degrees. The extremely hard compacted soil has prevented the plants from sending down a straight taproot!*

Figure 22: *28th April 2015. About 12 months after commencing a trial in Onion Weed infested land. This photo was taken immediately after half (0.08 hectares) of the trial area of 0.16 hectares received its final cultivation to kill the Onion Weed that had germinated following soil disturbance in 2014. Beyond the freshly cultivated soil is the rest of the trial area. It has a green tinge to it, which is newly germinated weeds – Onion Weed and Wild Sage.*

continue growing and re-seed with Spear Grass without first eliminating the Onion Weed – using the Onion Weed to help prevent further salinity rise while waiting for the Spear Grass to germinate.

At this stage I am guardedly optimistic that the trial will work out as planned and that option (2) above can be avoided. However as each year passes, and it already may be too late, the land moves progressively closer to the situation where option (2), establishing the grass with Onion Weed still present, will be the only viable option.

On 9th April 2015, and three days after a significant rainfall event, I ran a small, subjective test at this location. In this cultivated soil, I was able to use just a shovel to dig a hole and examine the moisture penetration – see Figure 23. At 50cm deep I stopped digging, but could have continued – there was still good moisture levels in the soil at that depth. However, note that the top 10-15cm of soil is dry. Within three days the moisture had already soaked down into the deeper soil. Meaning that the surface salt was taken down with it.

Figure 24 shows a second hole dug to examine moisture penetration in the soil just outside the cultivated area – in the hard panned soil. In this case, before a shovel could be used to dig, a long posthole crowbar was required to first loosen the soil down to about 15cm. The soil moisture was negligible in this first 15cm and virtually ran out altogether after that depth.

But look back at Figure 23. There is a thin crust layer (2mm to 3mm thick) on the top that is a silver grey colour. The crust plus the colour are indications of salt in this 2-3mm of soil and this is of great concern. This indicates that the soil, prior to being broken open the year before, is worse than I had anticipated. This crust is a case of micro Capillary Rise. The rain that fell just three days prior to the holes being dug was a series of very heavy showers that battered the soft-top back into a thin hardpan again. After this happened capillary rise started to occur again with the moisture the rain brought. While some salt was taken down deeper into the soil in the open soil areas by gravity, a portion of the salt in the subsoil was drawn to the surface by capillary rise. Time will eventually tell if this amount of salt brought to the surface will ultimately be enough to prevent the sown Spear Grass from growing. But on its own it is a serious warning, necessitating a re-think of the options to be adopted in re-establishing native grasses. Furthermore, I suggest that the soil in any area to be revegetated should have the soil salinity levels tested.

Even without the danger of the clay areas becoming saltpans, the hard panning that is a precursor, is an issue of concern. Plant root growth is dramatically inhibited by hard panned soil. This alone has three serious consequences. Firstly, if any attempt is made to re-establish native grasses without first breaking up the hardpan, the number of years in which grass could grow will be markedly reduced. Then, even in suitable years for growth the number of weeks over the year when the grass can actively grow will be reduced. Thirdly, the grass, even though it is a far more aggressive plant,

Figure 23: *9th April 2015, three days after a significant rainfall event. A hole dug into cultivated soil reveals moisture penetration to beyond 50cm deep – the depth of the hole. This means that surface salt has been drawn down to at least this depth by rainfall seeping in to the ground. However, note that the top 10-15cm of soil is dry.*

Figure 24: *A second hole dug to examine moisture penetration in the soil just outside the cultivated area – in the hard panned soil. In this case, before a shovel could be used to dig, a long posthole crowbar was required to first loosen the soil down to about 15cm. The soil moisture was negligible in this first 15cm and virtually ran out altogether after that depth.*

The detractors of what I am advocating (active and practical restoration of native grassland) may claim that biodiversity in the soil will be destroyed or that we must not intervene. Take a good look at this picture. Where is the biodiversity here? It's nothing but introduced inedible or toxic weeds with rising soil salinity.

Figure 25: *A patch of vigorous native Spear Grass growing in a small enclosure, protected from all grazing animals. It was planted in January 2012 as individual seeds simply dropped into the enclosure. This photo was taken just after the rains in January 2015. The Spear Grass is still alive and greening up, while the Onion Weed is barely visible and the Wards Weed is dead – under the right conditions of reduced grazing pressure, Spear Grass will dominate.*

and can out-compete Onion Weed and suppress it (so long as grazing pressure is reduced), it will tend to exist only as scattered plants. All three of these factors ultimately encourage soil salinity.

Clearly in Figure 24, the land shown is good for nothing in terms of conserving a wilderness area and this is only a tiny fraction of thousands of hectares of the Reserve in a similar state. The detractors of what I am advocating (active and practical restoration of native grassland) may claim that biodiversity in the soil will be destroyed or that we must not intervene, but rather let nature take its course. They need to take a good look at this picture. Where is the biodiversity here? It's nothing but introduced inedible or toxic weeds with rising soil salinity. It has sometimes been suggested that my proposed plans for repairing the soil structure and sowing native grasses may be akin to treating the Reserve like a farm. This is simply not the case! I just want to see the return of native grasses for the wombat's survival. If this requires the use of some farm type mechanical equipment to achieve the necessary outcomes, it does not mean treating the Reserve like a farm.

We need to remember that both the climate and the weather become important factors to be considered in semi-arid regions. Being aware now (unlike settlers in the 19th century) that this is a semi-arid area, just one step down from being an arid desert, definitely discounts the notion that one can treat the Reserve like a farm. The skills needed to manage and return this country back to suitable land for wombats to graze and survive on, appear to be held by extremely few people. We need more people to learn about and put into practical action, the skills necessary to conduct this work. If people lack the observation skills and knowledge of this area, they will be unable to see the tragic future outcome if we choose to do nothing.

Native Spear Grass and Wallaby Grass as well as Onion Weed, are perennial plants – plants that can live for a number of years, as opposed to annual plants that die off sometime during spring and don't grow again until enough rain falls in autumn and sometimes as late as winter. On average, annual herbaceous plants, such as Wards Weed, only extract topsoil moisture over a period of 4-5 months of the year – at a time of year when evaporation from surface soil is also minimal. Consequently much of the rain falling over the hotter periods of the year, from about October to around the end of May (which is frequently as much as or more than a third of the total annual rainfall), remains in the top soil and is drawn to the surface by capillary rise and evaporates. Leaving behind on the surface, the salt content of the rainwater itself, plus salts from deeper in the soil.

This means that semi-arid areas are more prone to rising salt than the wetter districts. Rising salt would have started to occur not long after Wards Weed replaced the regular presence of native grasses. The arrival of Onion Weed would have temporarily halted the salt rise and it is important to also note that the Onion Weed invaded the clay areas first, areas most prone to the affects of increasing salinity. But now the Onion Weed is starting to disappear from these clay areas, so the process will accelerate. The Reserve is in danger of serious widespread decline – nature's course is becoming one of self-destruction.

Figure 26: *October 2014. Vigorous and dense Spear Grass at my Cambrai property. The soil was initially extremely hard panned from years of over-use. Over several years, I reversed the situation with very careful soil repair.*

Figure 27: *"After establishing Moorunde Wildlife Reserve, rain fell in 1970. Photo of Berna [Clements] on Moorunde amongst the Spear Grass (Stipa species), 1970" – Alwin Clements.*

Let me draw an analogy here. If you built a house of bricks or stone on a clay area and didn't install a damp course, the house would eventually suffer damage from rising salt damp. This is because the density of the bricks or stone enhances capillary rise and saltwater can rise some metres up a wall. The hard panned soil, left as bare ground without plant roots keeping the water table low, is not called rising salt damp (that's a builders term), it is called capillary rise.

Figure 25 is a photo of a patch of Spear Grass growing in a small enclosure, protected from all grazing animals. It was planted in January 2012 with individual seeds simply dropped into the enclosure. It is located in an area infested with Onion Weed and Wards Weed, on hard panned soil. Since January 2012 the enclosure has protected the soil from further wombat excavation. This photo was taken just after the rains in January 2015. Notice the Spear Grass is still alive and greening up, while the Onion Weed is barely visible and the Wards Weed (that also initially thrived because it was protected from grazing) is dead. However despite individual Spear Grass plants growing vigorously, it is still not a dense ground cover – unlike that shown in Figure 26, which is the Spear Grass on my property at Cambrai that I planted using machinery. Although this photo was taken in mid October 2014 (after winter) the object here is to illustrate the desired ground cover achievable when the hard panned soil is correctly repaired. Simply planting grass seed alone is not enough; the soil needs to be treated to break up the hardpan. Even if it has to be done without eliminating or suppressing the Onion Weed, and it is now quite possible that this will have to be the case.

The grass shown in Figure 26 also greened up after the January 2015 rain and has grown vigorously since. It now provides abundant green summer fodder for (in my case) sheep. Also illustrated is the fact that the Spear Grass readily grows, out-competes and smothers the Onion Weed present. To the point where Onion Weed on my property is of no consequence at all and if it does re-emerge as a nuisance weed, it would indicate to me that I am over-grazing my native grass pastures.

It is not impossible to re-establish native grasses on Moorunde. Yes, there are problems to address to do so, however these problems already have achievable solutions. If the decision is not made, nor the necessary actions undertaken, to attempt to achieve a result similar to that shown in Figure 26, on the former Grasslands and open Myoporum Woodlands of Moorunde and the Twelve Mile Plain, it will be an act of culpable conservation negligence.

Figure 27, taken in 1970 by Natural History Society member Alwin Clements, shows a vast area of native Spear Grass on the nearly established Reserve. Native grasses were definitely once present and abundant on Moorunde and the Twelve Mile Plain! And it can be restored, as long as appropriate action is taken.

Currently the only management plan policy on the Reserve is to eradicate the Onion Weed, along with certain other weeds (while no attempt to control or reduce Wards Weed or Thread Iris is even considered). Obviously, total eradication of the Onion Weed is not possible. So in practice, attempts are currently made to prevent its spread either by hand hoeing or spraying, which is also not effective over the broad scale area involved. Given

Figure 28: *A wombat near its burrow, photographed on 20th May 2012. At first glance it doesn't look to be in bad condition. But look at the closer image in Figure 30 below.*

Figure 29: *A closer image of the same wombat shown in Figure 29 above. Careful inspection shows the real emaciated condition revealed by protruding ribs and hips. Looking back at the wide view in Figure 29, it is easy to miss the real state of their health with just subjective observation at a distance*.

that the weed, on some very large areas is all that is standing between the ground becoming completely grazed bare, this policy is not just wasteful of limited labour resources but counter-productive and potentially destructive. It also, in effect illustrates a "mind set" that is not only condoning, but also practising the old farming methods of the past that have led to so much agricultural land in Australia being rendered useless by rising salt.

American scientist and current Professor of Geography at the University of California, Jared Diamond says:

"As for the extent of salinization, it already affects about 9% of all cleared land in Australia, and that percentage is projected under present trends to rise to about 25%…. Once salinization has been initiated, it is often either poorly reversible (especially in the case of dryland salinization), or prohibitively expensive to solve, or solutions take a prohibitively long time." [Diamond]

Now take a look at the wombat photographed on 20th May 2012 in Figure 28. At first glance it doesn't look to be in bad condition. Figure 29 is a closer image of the same wombat and careful inspection reveals that the animal is some what emaciated (note the obvious ribs and protruding hips). It illustrates the potential for the real state of their health to be easily overlooked with just subjective observation. These photos were taken with a cheap little $90 camera with limited zoom, yet I could approach this animal quite close, as it was almost blind.

The wombat in Figure 30 was humanely euthanized in July 2012 due to its pathetic, nearly dead state. It did not have the energy to move away from me. Note here there is no hair loss; but the backbone and hips are protruding – it is emaciated. The animal's stomach contents were subsequently examined as shown in Figure 31. It was starving, with a stomach full of toxic Thread Iris tops. The wombat shown in Figure 32 was euthanized in September 2012. It was taken to the Roseworthy Campus of the University of Adelaide, for autopsy by their Veterinary Officer – it too was starving to death on Thread Iris tops. I have written about these wombats in other articles along with these pictures. When I said in February 2015 "you won't find animals like this now. They are all dead and the survivors are currently managing without distress", the wombat in Figure 32 being the last to be euthanized in 2012. However I did predict that the time would come when they would start to die off rapidly again. Three years later, that time has now unfortunately come.

Since then many more have been seen like this (and photographed by members) and numerous warrens have the stench of rotting carcasses emanating from the burrows – one cannot photograph this nor count the blowflies. Recently in July 2015, during a regular animal and vegetation survey on the Twelve Mile Plain, I counted six such warrens along a 2.5km loop within a one square kilometre area just north of the Moorunde campsite. This is not a natural mortality rate. My point is, that if farmers kept their animals over prolonged periods of time in this sort of condition, they would be open to prosecution by the RSPCA. Why are conservationists exempt from such responsibilities with *their* animals in *their* care on *their* land? Especially, when the cause is known and is preventable.

Now, however it is not just the welfare of Moorunde's wombats at stake, but also the ultimate fate of the Reserve. The remaining Figures 33-40 show some examples of the beginnings of saltpans caused by salinity rise. It's been suggested that I should monitor and document these areas with "scientific methods" and record the data in a "scientific manner" so that what I claim will be taken seriously and then "acted upon". I have already commenced and will continue to undertake this monitoring and recording. But the problem is once you see land like it looks in Figures 33-40 the red warning light is already on!

The land needs to be actively managed. It is blatantly obvious that we cannot sit by as passive observers doing nothing more than crossing our fingers and hoping for the best.

Sadly the managers of Moorunde and the Twelve Mile Plain Wild Life Reserve have for years now refused to see the warning signs and listen to advice gained from years of study, research and experience. It's not a question of when, as time has already run out, but if, they will honour their responsibilities to the wildlife under their care and demonstrate to the Society's supporters that the best possible actions are being undertaken to protect these creatures and that donated funds are being spent on these activities.

In the words of David Bowman, Professor of Environmental Change Biology at the University of Tasmania:

"It is wrongheaded to ignore the ecological impact of a long history of Aboriginal burning. In Australia ecologists cannot retreat to the 'wilderness' to study an archetype of nature because the 'wilderness' has long included people."

[Bowman]

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Figure 30: *This wombat had to be humanely euthanized in July 2012 due to its pathetic, nearly dead state. It did not have the energy to move away from me. The animal's stomach contents were subsequently examined as shown in Figure 32 below. Note that there is no hair loss on this animal, but the protruding hips and loose skin give away the true emaciated state – an easy thing to miss when seen at a distance.*

Figure 31: Examination of the stomach contents of the animal shown in Figure 31 above indicated that it was starving, with a stomach full of toxic Thread Iris tops – some of which are highlighted in the red circle.

Figure 32: *This poor creature was found and had to be euthanized in September 2012. The body was taken to the Roseworthy Campus of the University of Adelaide for autopsy by their Veterinary Officer. This wombat was also starving to death on Thread Iris tops. Note the emaciated condition, protruding spine, fur-loss and scabby skin.*

Figure 33: *An example of the beginnings of saltpan formation on the Twelve Mile Plain, caused by salinity rise. This site is located along Red Tank Track in the northeast area of the reserve. June 2015.*

The remaining figures show more examples of the beginnings of saltpans at various locations on the Twelve Mile Plain.

Figure 34: *Another example of a saltpan forming on the Twelve Mile Plain.*

Figure 35: *Another example of a saltpan forming on the Twelve Mile Plain.*

Figure 36: *Another example of a saltpan forming on the Twelve Mile Plain.*

Figure 37: *Another example of a saltpan forming on the Twelve Mile Plain.*

Figure 38: *Another example of a saltpan forming on the Twelve Mile Plain.*

Figure 39: *Another example of a saltpan forming on the Twelve Mile Plain.*

Figure 40: *Another example of a saltpan forming on the Twelve Mile Plain.*