A PICTORIAL SYNOPSIS OF AGRICULTURAL IMPACTS ON AUSTRALIAN VEGETATION

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Abstract

Paintings and photos illustrate changes to vegetation associated with agricultural development in Australia. The natural vegetation is illustrated using early paintings and recent photos of little impacted vegetation. The nature and severity of agricultural impacts are illustrated using historic and recent photos. The degradation of vegetation arising from agricultural land use is discussed in relation to desertification and hence global warming.

Introduction

Many comments have been made concerning the nature of the vegetation that existed in Australia prior to European settlement where all contain high uncertainty due to the very limited records. The general views are summarised in the map of pre European vegetation in the Australian Atlas of Natural Resources (ANRA 2001).

The map of Australian vegetation existing pre 1770 was initiated by Canahan in the 1960s, and was developed on the assumption that remnants of native vegetation existing at that time provided a reliable indication of the pre 1770 condition. Developments of the map since then in the Australian National Resources Atlas also incorporate this assumption, with the 'upgrades' being based on more comprehensive information on remnant vegetation and soils than available to Canahan. It has been assumed that the current distribution of prominent plant species (mostly trees) has not significantly changed due to either land use or change in climate.

One consequence of this assumption is the conclusion that land clearing has greatly reduced the total number of trees in Australia, and this has been used to justify extensive tree planting programs. However, no evidence has been presented to justify this conclusion other than to give figures on the extent of reasonably recent clearing. There has been no serious examination of the question as to whether existing remnant native vegetation provides a reliable indication of the pre 1770 situation by way of species occurrence or vegetation structure.

There are likely more trees now than in 1770 due to the response of native vegetation whereby woody plants are promoted relative to grasses by grazing. Extensive development of woody species in cleared and natural grassy areas has produced a major change in the structure and species composition of vegetation.

The influx of woody species into naturally grassy woodlands was attributed to desertification by Tunstall (2008). Soil compaction was seen as increasing surface runoff and thereby reducing the availability of water for the bulk of the vegetation. However, while this has occurred, it now appears that another mechanism is of greater importance. Plants have the ability to acquire atmospheric water by indensation (Tunstall 2009 a, b). Damage to vegetation through clearing and grazing therefore decreases the water available for plant growth. In effect, clearing the native vegetation, or degrading it through grazing, removes a major part of the water input into the system. Desertification primarily arises through damage to the vegetation decreasing the input of water, and changes to soils reinforce the effects.

Vegetation is typically seen as responding to climate, but through indensation it has the ability to greatly alter the climate as transpiration of water by plants is significant for regional rainfall. The initial consequence of damage to vegetation is a decrease in water input through indensation, but this flows on to rainfall whereby it also decreases. The positive feedback of degradation to vegetation decreasing the water input, and thereby further decreasing the vegetation, can send the system into a downward spiral such that it continues to degrade without any change in the land use.

Early landscape paintings and more recent photos are used to illustrate the nature and severity of impacts to vegetation produced by agricultural development in Australia. The focus is on woodland areas because they have been most impacted by agriculture. The likely form of pre 1770 vegetation is first addressed prior to summarising the changes produced by agricultural land management.

The examples given should not be directly applied to other forms of vegetation for, while most vegetation has changed, the forms of change can differ. For example, forests in southern mainland coastal forests appear to have become less dense even without there being any direct impact such as clearing. There are also scaling issues, as with forms of vegetation that appeared naturally to occur in small patches now occurring in extensive stands.

Image Sources

Selected paintings by Cooper of Challicum Park in southern central Victoria held by the National Library of Australia provide the main record of the form of vegetation prior to major land use change (ref. NLA). These depict areas around 37° 29'S, 143° 11' E, and date around 1842-1853. A comprehensive coverage of the paintings and description of the circumstances is given by Brown (1987). A painting by Hoddle of Ginenderra Plains in the ACT (nla.pic-vn3423118-v) provides similar information but not as comprehensively or clearly.

Most of the photos used were obtained from web sites, the main ones being government departments or quasi government agencies involved in land management. The main non-agency site used provides photos around the world on a 1 degree lat-long grid (www.confluence.org).

Pre development vegetation

Challicum Park

The most noteworthy feature of the painting of Waterloo Plains (**1**) is the scarcity of trees. Additional to the largely treeless plain, there are no trees on the skeletal slope where the painter was located. The trees on the hill in the distant left are sparse.

The low density of trees on hills is distinct in **2,** but this also illustrates their stunted form of low height and poorly developed trunks. The form of the trees is consistent with their developing at low density while being subject to severe impacts that damage their crown. Many have multiple trunks where this arises with eucalypts where the initial single trunk is killed. This limited occurrence of stunted trees is further illustrated in **3**.

Sheep Station Forest (**4**) likely indicates the maximal development of trees. By current standards this is open woodland and not forest due to the low density and moderate height of the trees. The trunks do not have the straight form that arises with forest grown trees.

Trees are also sparse in the vicinity of the creek (**5, 6**) but these paintings are most notable because of the extensive dense grassland and the large placid pools of water. This formation of interlinked pools has been termed chain of ponds.

The existing situation at the location of the paintings is unknown but the general situation is that hills would have a dense cover of trees, and the trees would have a forest form of a well developed single straight trunk. There is now also often growth of woody vegetation on the flats where the trees similarly do not exhibit the degraded form depicted in the paintings. The large amount of water in the creek would definitely not exist now, nor would the dense grass growth.

Intact native Vegetation

It is exceedingly difficult to find any native vegetation that has not been directly impacted by land use because the land resources have been exploited to the maximum extent possible with the available technology. In particular, it is almost impossible to find non-impacted woodlands because livestock were allowed to graze anywhere they chose, and woodlands provided prime grazing in the early stages of European settlement. Changes in vegetation from these cause would be superimposed on those associated with the change in the fire regime. For these reasons alone recent photos of intact vegetation do not necessarily identify what the pre 1770s vegetation was like.

The above limitation is compounded by degradation to regional vegetation decreasing the water input into the system where this would negatively impact on all vegetation. Excluding land use from a patch of vegetation does not necessarily prevent it from being subject to impacts from the surrounding land use.

Chain of Ponds

Accepting the limitations, photos of some native vegetation can provide an indication of the pre-1770 situation. The chain of ponds (**7, 8**) in the SE tablelands of NSW have the same form as the creek at Challicum Park. The surrounds are grassy and ponds contain water during the dry.

The Gungahlin site (**9**) is a natural drainage line in a small catchment that is dammed above the photo, and it is now surrounded by urban development. Ponding of water occurred across several hectares throughout winter despite a severe drought and the blocking of surface water inflows by dams. While the hydrology of the site would be essentially impossible to unravel it appears to function as a natural dew pond. While the vegetation acts as the indenser the specific location of this site is particularly significant.

SWBTA

The Shoalwater Bay Training Area (SWBTA) is located on the Queensland coast just north of Rockhampton. It had been subject to very low intensity grazing and selected timber felling prior to acquisition for military training in the late 1960s. These impacts were progressively removed along with impacts of feral animals such as pigs. Moreover, the fire regime under Defence management has been changed to benefit the native vegetation rather than grazing.

Given the size of the area, its past use and current management, much of the vegetation is in near pristine condition.

The photos **10-13** are for woodlands in the west of the area. The most notable feature is the abundant grass, and this occurs despite shallow skeletal soils (**11**) and extremely low fertility (**13**).

The other feature is the poor tree development in some stands (**10, 11, 12**). Outside the training area such sites typically have a high density of well formed trees. The sites had never been cleared or logged, and the woody vegetation has never been specifically impacted by land use.

Deserts

The photos of desert vegetation (**14-19**) were obtained for national parks were possible. Any grazing impacts should be minimal.

The vegetation in the photos is predominantly perennial, and encompasses trees, shrubs and grasses. The development of herbaceous ephemeral plants following rain is additional.

The significance of the photos is the maintenance of a good cover of perennial vegetation despite the very low and highly irregular rainfall. The deserts are not bare but maintain a good cover of vegetation.

Agriculture

Crop lands

The photos of crop lands (**20-25**) are for what are generally considered to be natural woodland areas. The low and variable rainfall means that crops often fail (**23**). The current 'best practice' involves maintaining a bare fallow for an extended period before planting a crop, which usually translates into the land being bare except when planted to a crop.

The ground is kept bare to increase soil water when, with plants functioning as indensers, the denudation of vegetation prevents the accession of large amounts of water that would have been obtained by the native vegetation. The farming practice is well designed to produce desertification, but the deserts will take the form of bare ground and shifting sands rather than the vegetated systems in central Australia.

Grazing lands

The grazing land photos (**26-31**) are for more arid areas than for crop lands, and address the grazing of native vegetation without clearing. The effect is equivalent to that with cropping in producing extensive areas of bare soil. The main differences are the odd remnant woody plant, and the obvious occurrence of soil erosion. As with cropping, the effect of grazing across large areas is to prevent the accession of water through indensation by plants thereby significantly decreasing the input of water into the system.

Water erosion

The photos for water erosion (**32-38**) illustrate that agriculture has increased the loss rainfall through surface runoff, and the loss of fertile topsoil, while reducing the area of land supporting vegetation. The channel erosion prevents the occurrence of chain of ponds (**32**).

Channel erosion serves to increase the aridity of the system by promoting water loss through surface runoff and reducing the accession of water through indensation by plants.

Wind erosion

Wind erosion (**39-44**) typically arises through the denudation of vegetation. While strong winds are causal their velocity at the ground is naturally reduced by vegetation. The land management practices that promote wind erosion are clearing (**39, 41**), fire, and grazing (**30, 31**).

Wind erosion arises through degradation to vegetation. However, its occurrence promotes further degradation of the vegetation as the eroded top soil typically contains most of the readily available plant nutrients. The degradation to vegetation through loss of nutrients produces a downward spiral in vegetation development as arises with water erosion.

Constructed Drainage Channels

Many agricultural areas throughout the world have been developed by draining waterlogged land. The low rainfall limited this practice in Australia but the construction of drains has still occurred in coastal areas (**45-53**). Some of these schemes have been massive, as with the Upper South East (USE) drains in South Australia (51-53). Such drains increase the aridity of the system.

Native 'Woody Weeds'

Woody weeds largely represent the encroachment of shrubs into what were grassy areas used for grazing (**54-59**). Many of the areas were naturally grasslands but, due to the encroachments, have been subject to successive waves of clearing of the invasive woody plants.

The invasive woody plants are viewed as suppressing the development of grasses when the woody plants arise because the grasses have been suppressed by grazing. The woody plants are the only thing that holds the system together thereby preventing much more rapid decay into a desert.

Exotic Weeds

Similarly to native 'weeds', exotic weeds typically invade when the prior vegetation is degraded through clearing or grazing. Attempts to maintain bare ground to promote selected crop and pasture species render the land suitable for many species (**60-65**).

From an agricultural perspective the invasive plants are damaging, but for the functioning of the system they are beneficial. Prickly acacia, for example, invades where grazing has damaged the native Mitchell grass (**60**). Its growth improves the functioning of the system by increasing water and nutrient gains. Similarly, Patterson's curse invades highly overgrazed areas and so stabilises a highly deleterious situation (**62**). Its success partly arises from its toxicity to the horses that are commonly responsible for the overgrazing.

Prickly Pear

Prickly pear (**66-70**) was unusual in invading intact native plant communities. Some communities would have been heavily impacted by grazing, but not necessarily all. For example, brigalow communities naturally contained little grass and so could have been little impacted by grazing. Regardless, all brigalow communities became heavily infested (**69**).

The emphasis in the 1920s was on pear eradication hence detailed observations of the interactions between the prickly pear and native plants appear not to exist. From the photos (**66-70**) the grasses and all other ground layer species appear to have been completely suppressed, if not eliminated. From the development of the tree canopies where the cactus was poisoned (**70**) it appears that the cactus appreciably suppressed the growth of the trees.

The question is why prickly pear was so successful in invading the native vegetation, lack of predators and pathogens for the cactus aside. Cacti appear to depend on indensed water for growth to a much greater extent than Australian native plants. An ability to out perform the native vegetation in gaining water through indensation would confer a considerable advantage. For example, the grass *Themeda triandra* that was originally abundant across large areas of Australia has a distinct advantage over many other grass species in its capacity for indensation that is likely held by some modern eucalypts, that of being functional while the leaf is in motion due to wind.

Cacti can store indensed water in their fleshy tissue whereas most native plants appear to rely on the soil as their water reservoir. The prickly pear could therefore retain all of the water it indenses while having the potential to obtain some of the water indensed by native plants.

Discussion

While Tunstall (2009a) compared agricultural fallows to deserts the Australian deserts have much more vegetation than exists in cropping fallows. The same applies with grazing of native vegetation where the land is effectively denuded of green vegetation except for brief periods following rain. This removal of vegetation by grazing is compounded by erosion whereby all erosion reduces fertility and therefore plant growth, and water erosion additionally reduces the amount of water and land available for plant growth. All agricultural practices serve to greatly reduce the occurrence of green vegetation and increase the amount of bare soil.

The issue is not the clearing of native vegetation per see but the maintenance of bare soil, be it intentionally or otherwise. The adverse consequences of this practice that have long been known include soil compaction and erosion, and the loss of soil organic matter. An additional adverse consequence is the lack of accession of water through indensation. The lack of green vegetation reduces the input of water into the system.

The results of Bell et al.(2001) provide insights into how the system naturally functioned. They identify that the amount of rainfall not transpired by the vegetation was the same for degraded and remediated grassland. The water loss was therefore the same for both situations, but it occurred through surface runoff in the degraded system and by deep drainage (percolation) in the remediated system.

A characteristic of studies such as Bell et al. is that not all components of the water balance are measured. The water use by vegetation is assumed to be the difference between the input from rainfall and the losses from runoff and percolation. However, the estimate of water use includes water evaporated from the soil as well as water transpired by plants, and there is no reliable way of separately estimating these components. Traditionally the much greater grass growth in the remediated system could only be explained by reduced water loss through direct evaporation but there is no reliable way of showing that this is the cause.

Reduced runoff in the remediated system would be expected due to the improved soil structure, but the occurrence of drainage through this soil is difficult to explain given the improvements in soil water storage capacity and the capacity of the vegetation to exploit it. The same situation arises with conversion to cell grazing. Surface runoff often ceases but springs can develop, and there is a large increase in plant production with little apparent increase in plant water use.

Acquisition of water through indensation provides an explanation for increased growth without increased water use, as observed by Bell et al. and with cell grazing. The essential requirement is the maintenance of a good cover of green vegetation. The occurrence of percolation can also be due to indensation. Grass plants have little capacity to store indensed water and must therefore utilise the soil. To be efficient this requires a high root density, which grasses have. It would also be promoted by the soil materials having a high capacity for water storage, such as clays, where grasses preferentially occur on such soils.

The use of soil to store water involves leakage regardless of the rooting density and soil type. Such leakage, or percolation of water, is logically responsible for the development of springs with cell grazing, and the existence of chain of ponds with the pre 1770 vegetation.

With chain of ponds the persistence of flows is maintained by water accessions through percolation. Surface flows are low in being limited to major rainfall events because of the permeability of the soil. The current situation is that percolation has greatly reduced, but runoff has increased due to soil compaction. The potential for recharge to groundwater systems has greatly declined due to the decreased water input into the system, and because of the greatly reduced percolation through soils. It is therefore not surprising that ground water systems are becoming dry, but there is no point attributing this to the construction of dams or the use of water for irrigation. It primarily arises because of the degradation to vegetation and soils caused by inappropriate agricultural land management.

Conclusions

Current cropping practices are designed to maximise the return from the transient growth of selected plant species by preventing the development of any other vegetation. This minimises the occurrence and development of vegetation and thereby minimises the indensation of water into the system by plants. The current 'best practice' reduces the water input into the system and is therefore well designed to produce desertification.

The outcome with broad scale grazing is equivalent to cropping but does not arise through intent. Attempts to retain stock through droughts inevitably degrade the vegetation, with the recovery of the vegetation decreasing with each episode. This degradation is greatly promoted by the practice of feeding stock during drought. The suggested pasture protection has represented stock protection with every effort being made to fully utilise any available pasture. As with cropping involving bare fallow, the inevitable long term consequence is desertification.

Given knowledge of the indensation the current decline in water in the Murray Darling Basin was inevitable given the agricultural practices. The situation can be remedied, but not by practices such as attempting to increase river flows by reducing irrigation. The amounts of water that can be returned to the river are trivial compared to the losses due to vegetation degradation, and these losses continue to increase with time. Remediation depends on changing the way in which agriculture is conducted such that the prime objective is the maintenance of a cover of green vegetation across all of the land for as much of the time as possible.

The current malaise of global warming can be seen to have arisen for several reasons, but all revolve around the desire for quick monetary gains and politically acceptable fixes. Scientists were involved as their considerations addressed the supply and use of water with effectively no regard to its production. However, the constraints and pressures imposed on farmers by the financial/business system represent the primary cause. The thrust has been that the land can be maximally exploited without sound knowledge of how the natural system works. The only criterion considered important has been that management inputs should provide an immediate increase in profit.

The dilemma is that the approach responsible for producing the damage is now being promoted as the means of obtaining a solution. Water trading was promoted as a solution for water shortages where it has achieved little more that providing windfall monetary gains for some. It certainly has not provided surety of supply for irrigators when this was its prime purpose. Similarly, carbon trading is being promoted as the cure for global warming when this will only provide symptomatic treatment while imposing considerable costs on farmers and the general public. More importantly, the symptomatic treatment of addressing CO2 will greatly increase the degradation through attempts to feed the existing population on a declining agricultural resource.

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- **2** nla.pic-an2681073-v
- **3** nla.pic-an2681090-v
- **4** nla.pic-an2685986-v
- **5** nla.pic-an2686378-v
- **6** nla.pic-an2686148-v

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Cooper paintings, Victoria

Challicum Park: View from Waterloo Plains looking towards Challicum

Challicum Park: Panorama No. V

Cooper paintings, Victoria

3

Challicum Park: Panorama No. Vii

4

Challicum Park: Sheep Station in the Forest

Cooper paintings, Victoria

5

Challicum Park: Fiery Creek

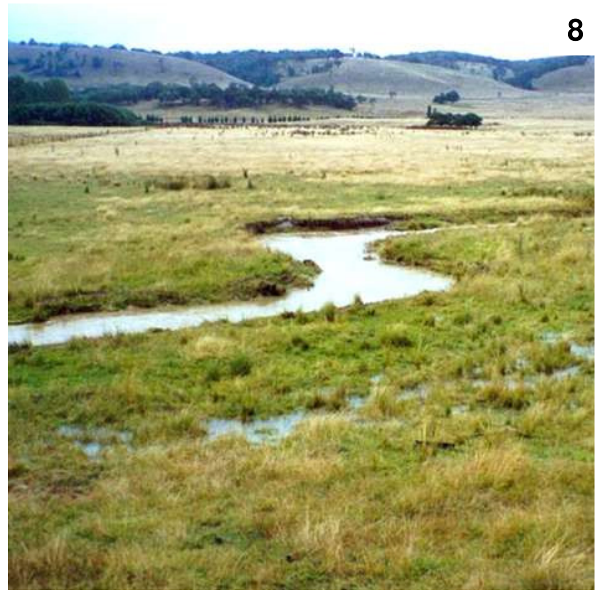
6

Challicum Park: Up the Creek

Somewhat natural Chain of Ponds

7

8



SE Tablelands, NSW

9

Gungahlin, ACT

Near pristine woodland vegetation, SWBTA

10

Eucalypts and melaleucas on lower slope

11

Eucalypts on hill slope

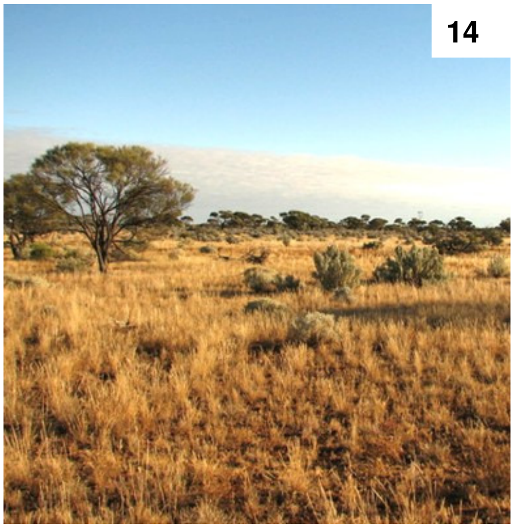
12

Eucalypts on a flat

13

Paperbarks (melaleuca) on a flat

Desert Vegetation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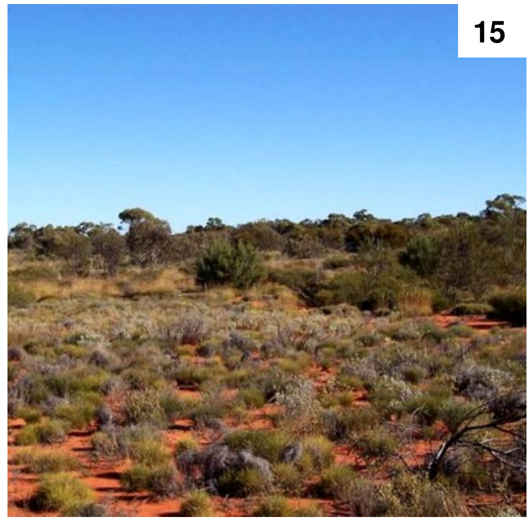
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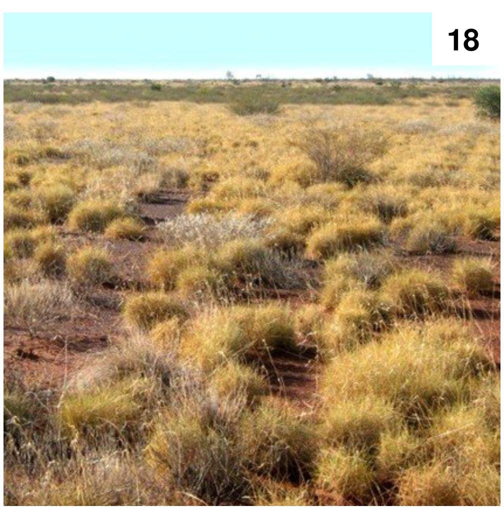
Great Victoria Desert


16


17

Nullarbor Plain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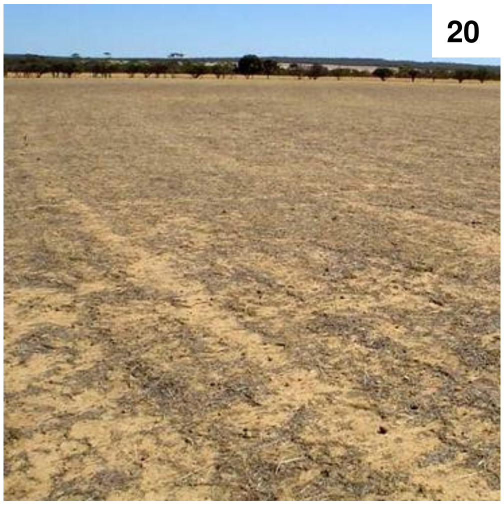
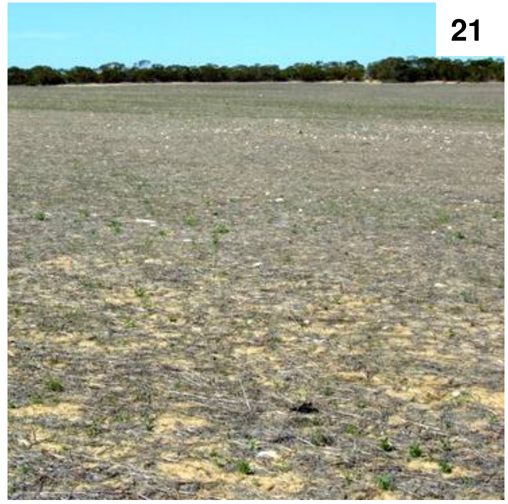
Gibson Desert

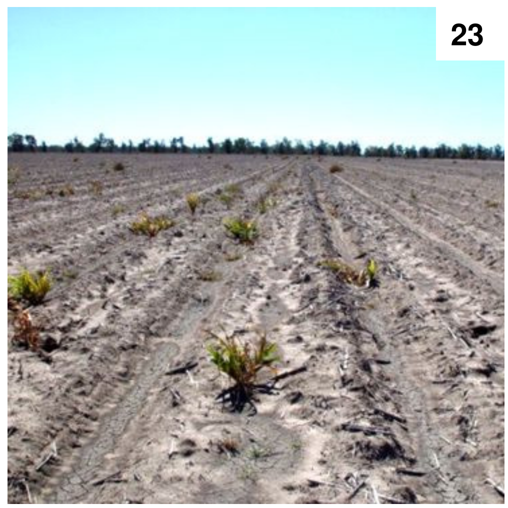
Crop lands



SE Western Australia



South Australia

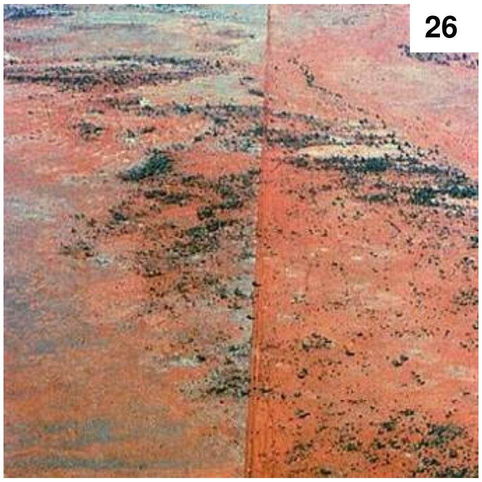


New South Wales

Victoria

Queensland

Grazing lands

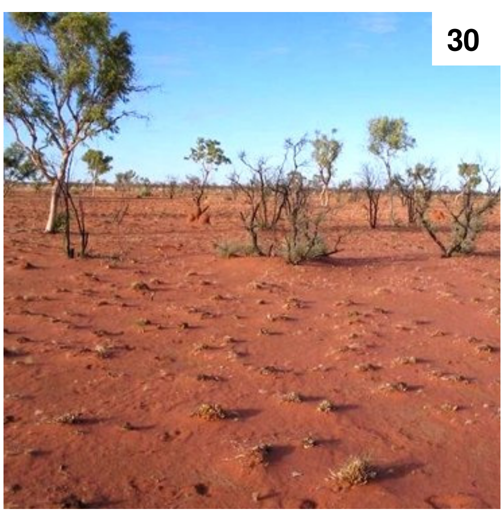


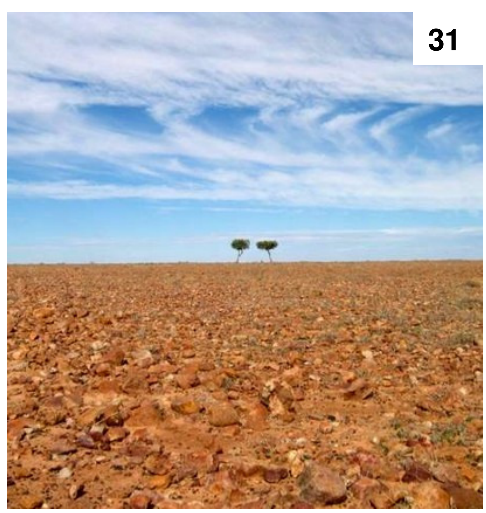
S Northern Territory

Central West Western Australia

South Australia

SW NSW



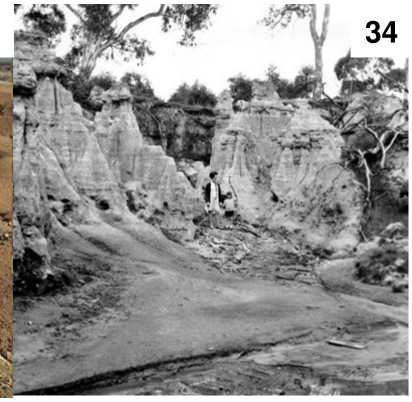


Western Queensland

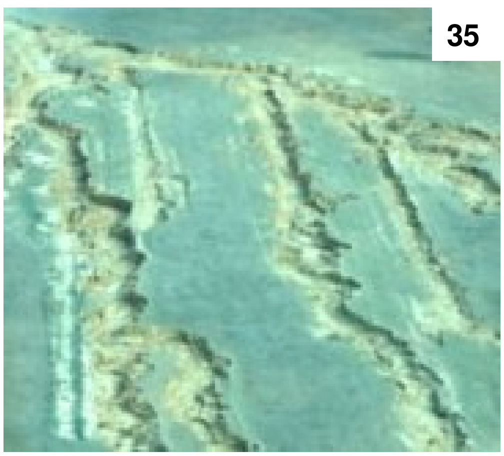
Water Erosion

NSW (ex chain of ponds)

NSW (ex wheat



NSW (Monaro)



Victoria (Wimmera)

Western Australia

Queensland (west of Cairns)

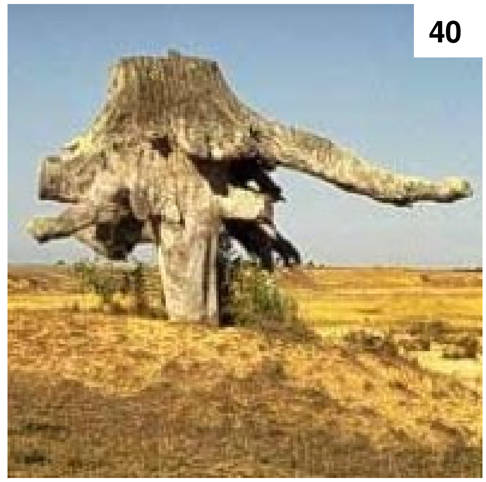
Northern Territory (near Todd River)

Wind Erosion and Dust Storms

39

Victoria (mallee)

40



Western NSW

41

South Australia

42

NW NSW

43

SW NSW

44

South Australia

Constructed Drainage Channels

45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Coastal northern NSW

Western Australia

48


Victoria

49


50


Tropical Queensland

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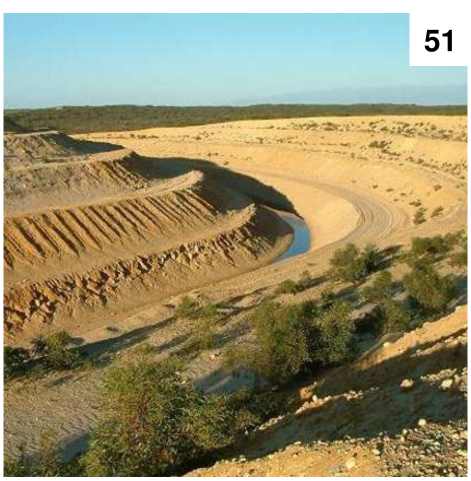

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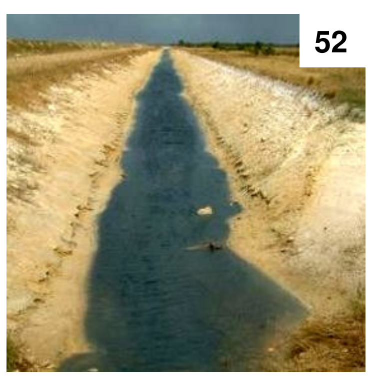

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South Australia, Upper SE

Native 'Woody Weeds'

Eucalypts & shrubs

Callitris & shrubs

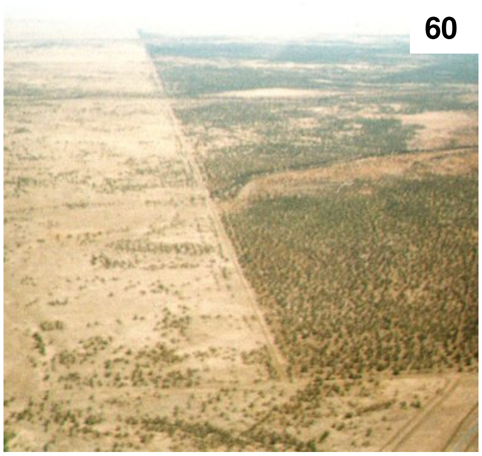
Shrubs

Mainly shrubs

Shrubs (vegetation never cleared)

Callitris (white cyprus)

Exotic Weeds



Prickly acacia

Wild tobacco

Salvation Jane / Patterson's curse

Bathurst burr

Parthenium

Mimosa pigra

Prickly Pear

66

Open eucalypt woodland

67

New England district, NSW
Sparse eucalypt woodland

68

Moree NSW (Belah)

69

Roma, Qld. (Brigalow – Belah?)

70

Control Treated
(Belah)

