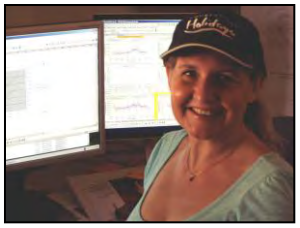
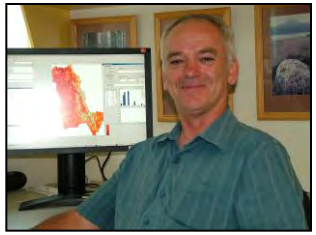
FUTURE FARM
INDUSTRIES CRC

EROSION
In Tarcutta Creek Catchment
Causes and Solutions






Aleksandra Rančić, Dr Ken Page, Brendan Christy, Terry McLean

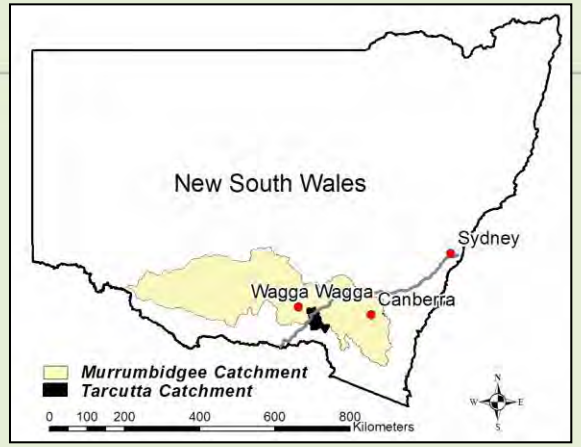
NSW GOVERNMENT

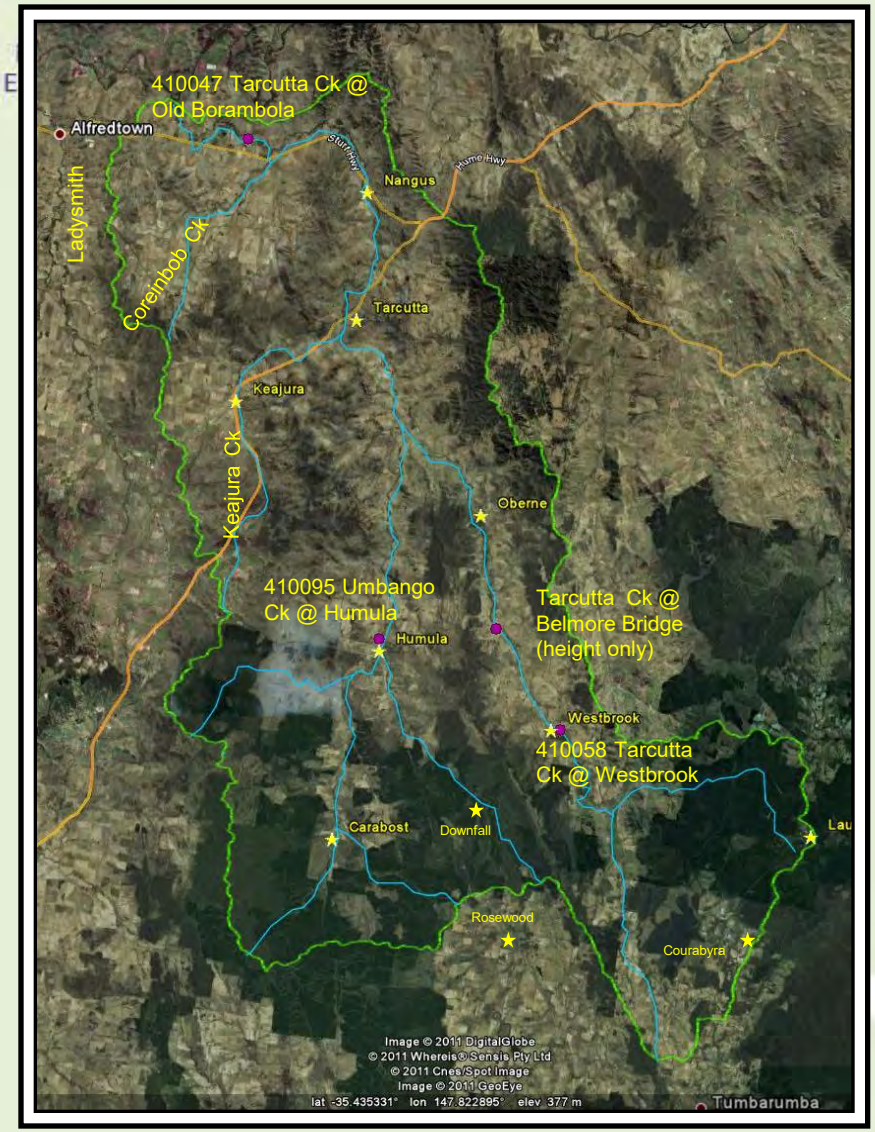
UNSW

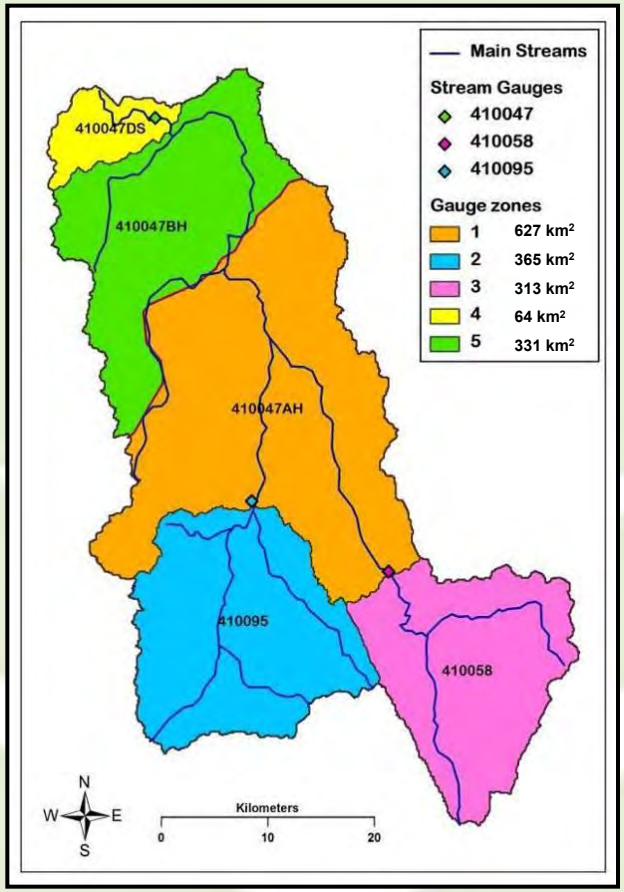
Charles Sturt University

Victoria
The Place To Be

Tarcutta catchment (1700 km²)







EROSION

- CAUSES:
  - Natural
  - Induced by changes brought in by European settlement
- ADVICE:
  - Range of solutions to reduce and combat the erosion

TARCUTTA CREEK
d/s of Janey Harvey bridge after removal of logs:

Deep incision and channel widening

Photo credit: Dr Ken Page

FUTURE FARM INDUSTRIES CRC

CAUSES OF EROSION

1. ENERGY DRIVEN PROCESS
   – Energy against binding forces in the soil or rock

- NATURAL :
  1. Some erosion is absolutely natural in the evolving landscape
  2. Existed on the Earth since its beginning
  3. All the soils are formed from rock by erosion
  4. In Australia some soils are naturally dispersive (in contact with water “melt” like ice cream)
  5. Wet and dry cycles induce channel changes (Erskine and Warner)
  6. Bare soil (fire, drought, waterlogging, salt), loss of binding forces

CAUSES OF EROSION

FUTURE FARM INDUSTRIES CRC

ENERGY DRIVEN PROCESS:

1. Wind - energy of wind vs. soil cover (Dust storms)

2. Water
   - Frozen: ice expands (freeze-thaw), glaciers
   - Liquid water – static:
     slope stability, slumps after the flood
   - **Liquid water – movement – energy of flow**

FUTURE FARM INDUSTRIES CRC

CAUSES OF EROSION

ENERGY DRIVEN PROCESS:

2. Water

Liquid water – movement – energy of flow

1. **SPEED**: 3 times faster water, 3x3=9 times more energy
2. **COVER**: 1/3 roughness, 3 times faster water
   - vegetation: height, bushiness (drought, fire)
3. **AMOUNT** of water: Flood : energy

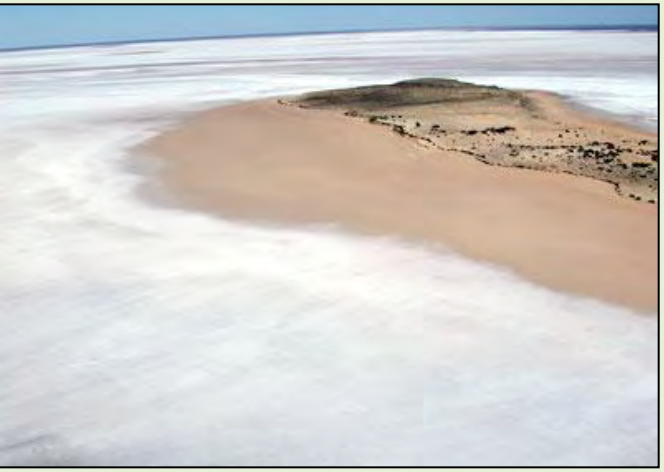
1.5 :	1.72
2 :	2.52
3 :	4.33
4 :	6.35

1. **SLOPE** 5%->10% (twice), faster water, double energy

FUTURE FARM INDUSTRIES CRC

CAUSES OF EROSION

- NATURAL :
  2. Naturally dispersive soil material:
     - Salt is a natural feature of some Australian soils
     - Salt creates dispersive soils when exposed to water
     - Kills plants – bare soil prone to erosion
     - 3 reasons for salt:



a) Some streams end in the centre of Australia (terminal basin)

» Evaporation leaves salt behind,

» Westerlies: salty dust (Parna),

» Deposit on slopes of the Great Dividing Range

b) Salt from rainfall and rock minerals

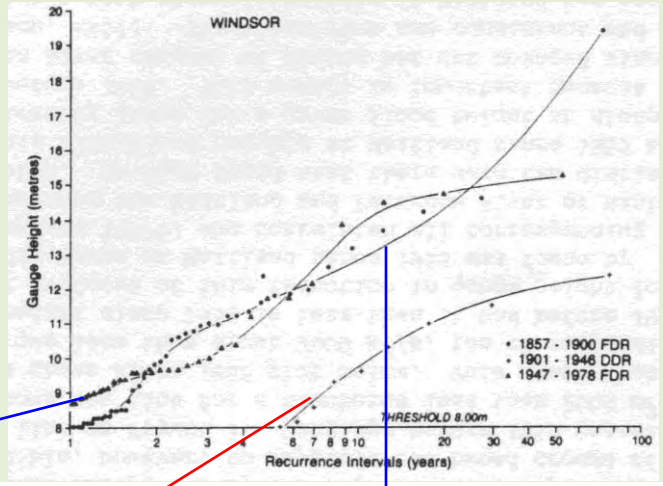
FUTURE FARM INDUSTRIES CRC

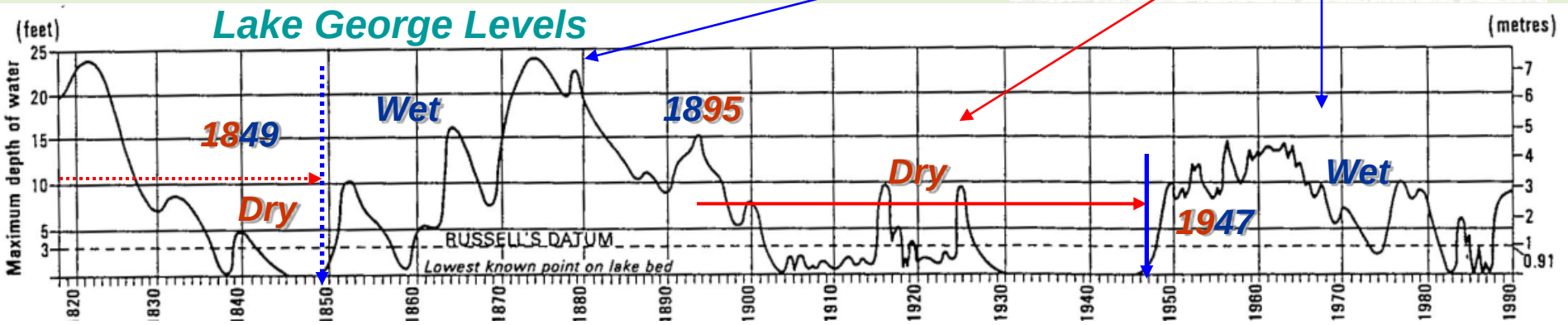
CAUSES OF EROSION

- NATURAL :
  - c) Combination of:
    - Periodic wet and dry cycles (next slide)
      - » Rise in watertable during wet cycles
      - » Water approaches the surface
    - Poorly drained soils
      - » Clay, flats
      - » Seeps, not springs
      - » Salt left behind by ET
      - » Poor salt wash off

CAUSES OF EROSION

- NATURAL :
  3. Chanel changes
     - Wet and Dry phases: Erskine and Warner
     - Alternating Flood (high energy) and Drought (low energy) Dominated Regimes persisting for 40 to 50 years





Jacobson G., Jankowski, J & Abell R.S. 1991, *'Groundwater and surface water interaction at Lake George, NSW'*, BMR Journal of Au Geology & Geophysics, 12, 161-190

- Rainfall ~15-20% higher 1947-2000 then 1895-1946 in most of NSW
- Only ~5% to max 10% in Tarcutta (winter rainfall zone)
- During FDR – channels widen, straighten; sometimes deepen.
- During DDR – channels recover: narrow, became more wiggly

CAUSES OF EROSION

- INDUCED BY EUROPEAN SETTLEMENT (Brierley and Co):
  1. Clearing + introduced animals
  2. Sandwich: loss of soil strength, increase in energy of water
  3. Channels deepen, widen, straiten, become steeper.

UMBANGO CREEK

Photo credit: Dr Ken Page

CAUSES OF EROSION

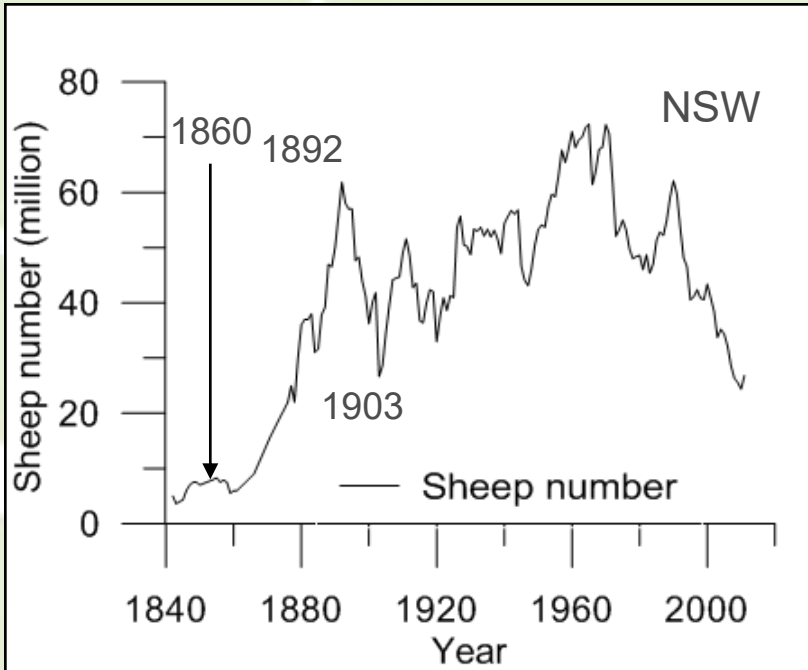
- INDUCED BY EUROPEAN SETTLEMENT:
  1) Clearing – Tarcutta catchment

- 1830s, squatting period: Mate & Bardwell
- 1848: Tarcutta catchment settled & leased by <10 pastoralists – predominantly sheep

Pastoral Runs:
Borambala
Umutbee & Toonga
Oberne Hoban
Kyemba (portion)
Oberne
Humula
Carabost
Bago
Coorabyra

- 1861: selectors – Robertson's Act
- Major clearing (ring barking) 1860-1892

- Rabbits arrived in 1884
- Overstocking – sheep numbers peaked in 1892
- Federation drought: 1895-1903 bare soil
- Tarcutta swamp drained



CAUSES OF EROSION

- INDUCED BY EUROPEAN SETTLEMENT:
  - Recent historic context – Tarcutta catchment

"In 1874 selectors were appearing over in the district in a grater numbers then ever before. Mate's view at a time was that the changes to the landscape, degradation of the environment and grater distraction of pastures and streams were due to overstocking, brought about by more and more selectors and increased number of sheep. Tarcutta Creek, when the Mates arrived there in 1830s looked like a chain of ponds, the water gliding from pond to pond and grass growing to the water edge. The trampling of sheep, with subsequent loss of protection to the soil, had helped convert a pleasant stream into what was becoming in places a deeply incised waterway with no attraction to the eye at all. In times of heavy rain, the rush of water scoured the banks, cut channels deeper and deeper and left the creek bone dry until the next rain."

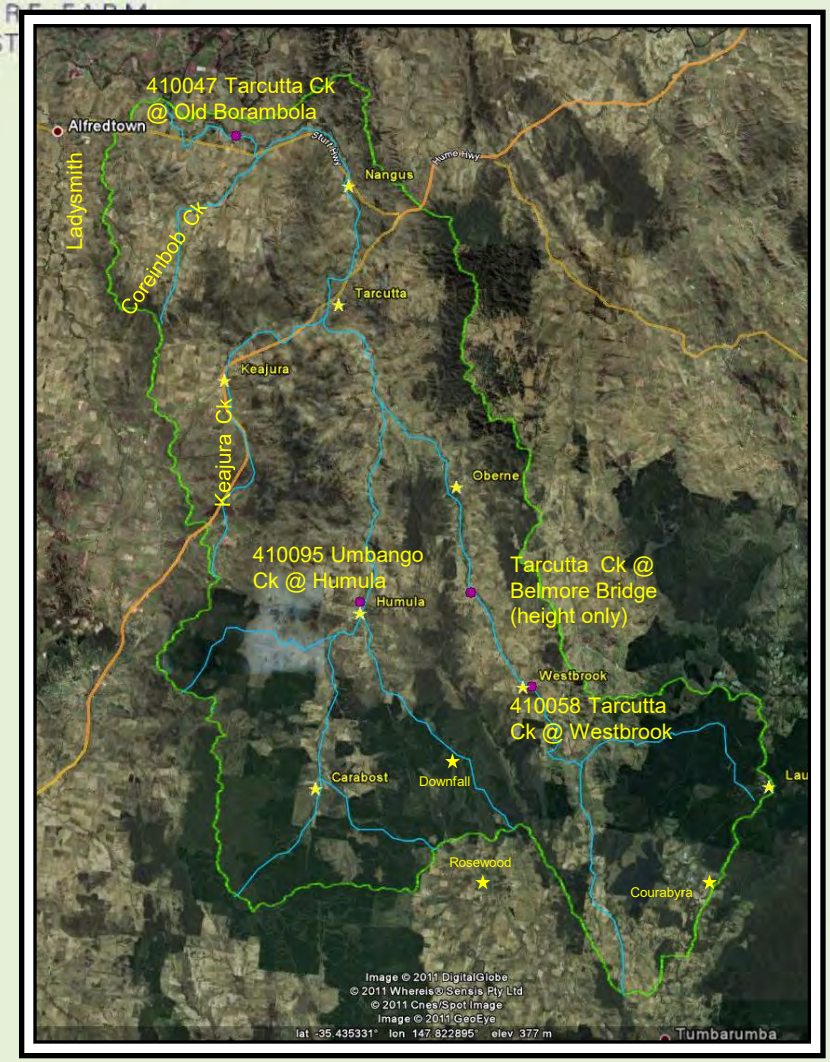
Docker "The Bardwells of Bardwell Park"

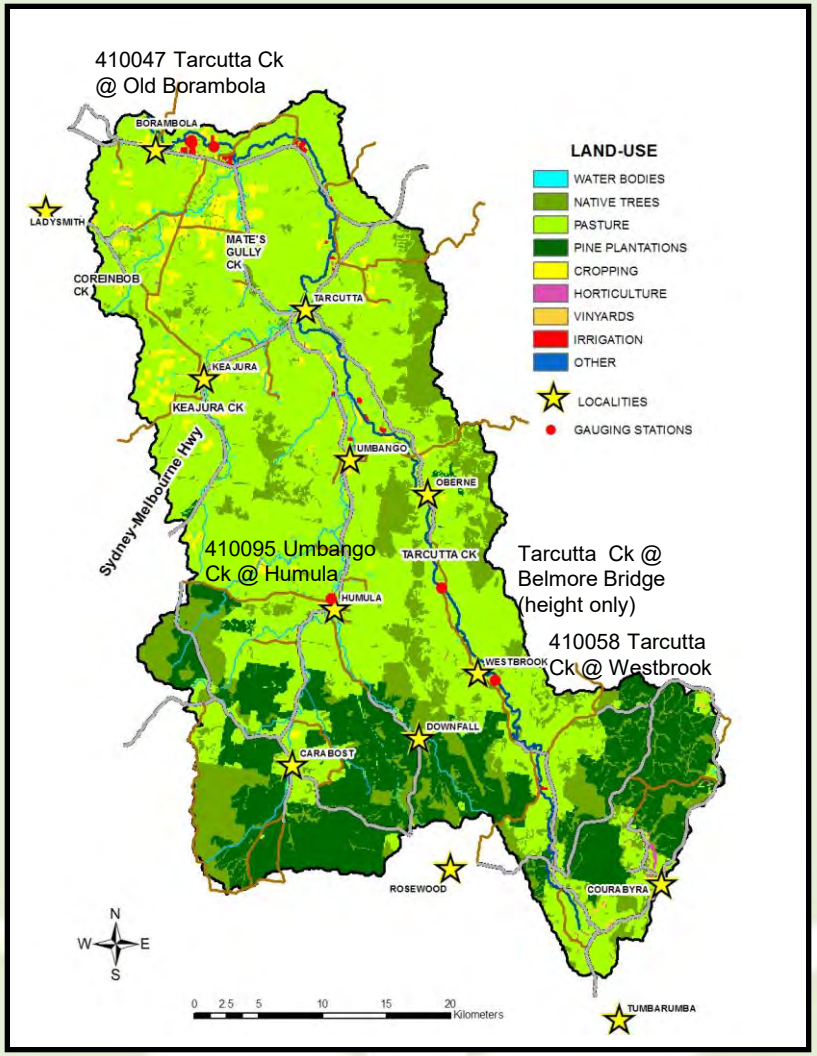
Photo credit: A Rancic

Photo credit: Dr Ken Page

CAUSES OF EROSION

- INDUCED BY EUROPEAN SETTLEMENT:

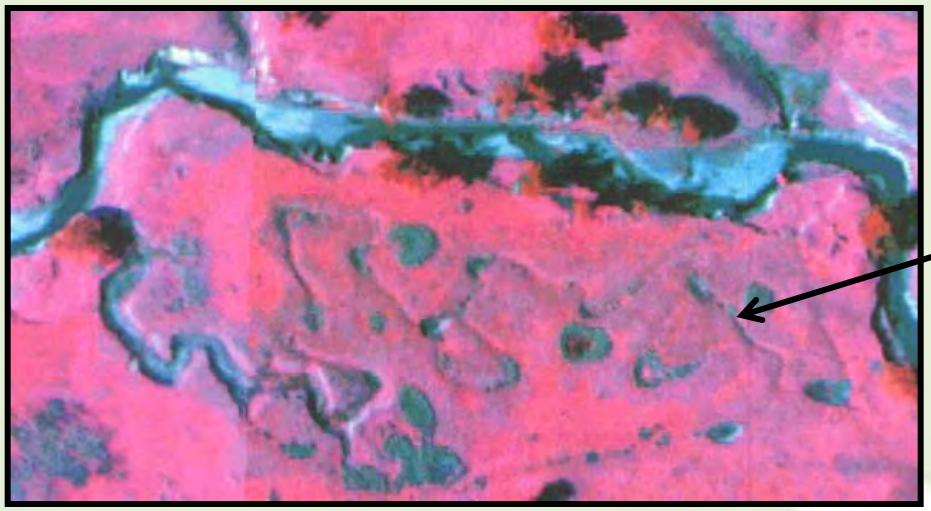




- 65% land cleared => reduction in ET and roughness, energy increase

Channel changes

- Land clearing increases runoff from rainfall
- Initially, hillslope gully erosion results in sediment being spread over floodplain (PSA) and filling the low-energy winding channel.
- Increased stream flow=> channel straightening and abandonment of the old winding course which is filled with sediment.



Pre-European settlement channel

False colour imagery

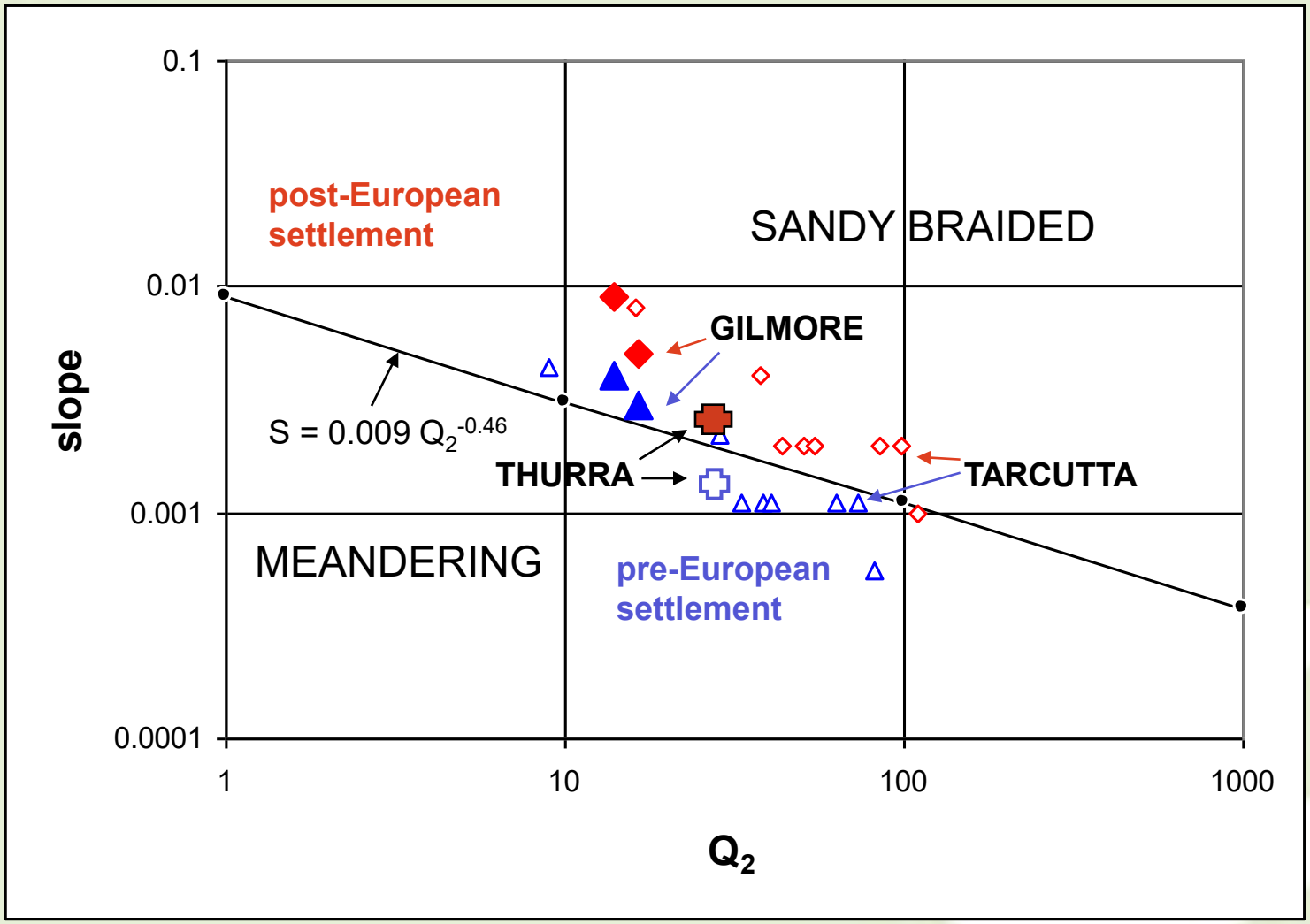
Umbango Creek

Credit: Dr Ken Page

- New, higher energy straighter gravel bed channel established and maintained to present. Very difficult to move away from this new equilibrium channel pattern.

Channel changes

Pre-settlement: Many mid-catchment streams [blue] close to meandering/low sinuosity threshold [steep valleys]



CAUSES OF EROSION

INDUCED BY EUROPEAN SETTLEMENT: roughness

Natural streams - minor streams (top width at floodstage < 100 ft)	Manning's **Roughness coefficient** n for Channels (Chow, 1959).		
1. Main Channels	**Minimum**	**Normal**	**Maximum**
a. clean, straight, full stage, no rifts or deep pools	0.025	**0.030**	0.033
b. same as above, **but more stones and weeds**	0.030	**0.035**	0.040
g. sluggish reaches, weedy, deep pools	0.050	**0.070**	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	**0.100**	0.150
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	**0.030**	0.035
2. high grass	0.030	**0.035**	0.050
b. Cultivated areas			
1. no crop	0.020	**0.030**	0.040
3. mature field crops	0.030	**0.040**	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	**0.050**	0.070
5. medium to dense brush, in summer	0.070	**0.100**	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	**0.040**	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	**0.100**	0.120

Main Channels	
Roughness	**60%**
Speed	1.67
Energy	**2.77**
Floodplains	
Roughness	**1/3**
Speed	3
Energy	**9**

CAUSES OF EROSION

- INDUCED BY EUROPEAN SETTLEMENT:
  - Energy driven process, liquid water:
    - 1/3 roughness, 3 times faster water (clearing, overstocking, removal of litter, rabbits can half the roughness) **[60% => 1.67]**
    - 3 times faster water has 9 times more energy **[1.67 => 2.77]**
    - Flood : energy – less ET, **~3** x more water, **4** x more energy

      1.5 : 1.72
      2 : 2.52
      3 : 4.33
      4 : 6.35

      [2.77 X 4.07 = 11.3]

    - Slope 5%->10% (double), faster water, double energy

CATPlus	Streamflow	Streamflow* / Catchment Area	Increase in streamflow	Increase in energy
1900-2009	(ML/year)	(mm/year)		
Current land use	146200	86	2.87	~ 4.07
100% trees	51000	30		

*Amount of rainfall that ends up in the stream

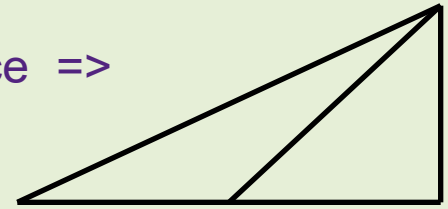
CAUSES OF EROSION

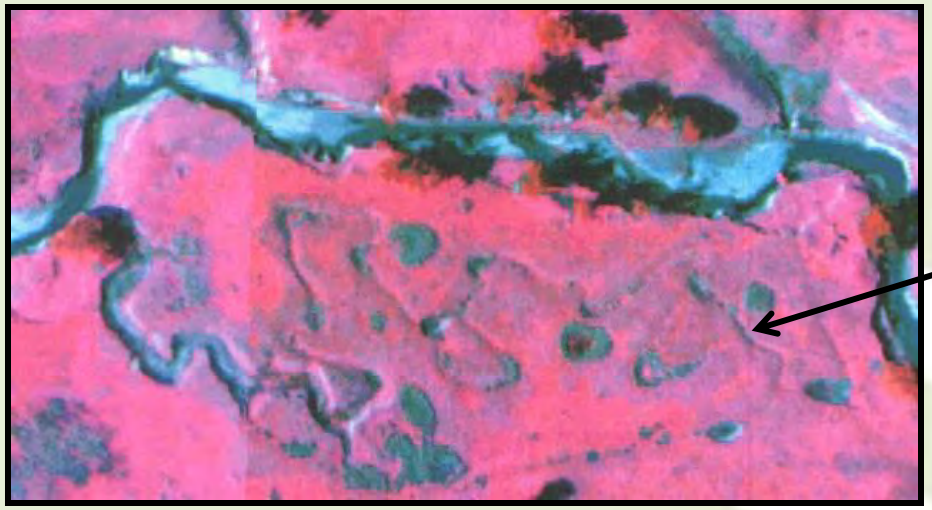
FUTURE FARM INDUSTRIES CRC

INDUCED BY EUROPEAN SETTLEMENT:

Changes in stream channels:

- More energetic flow tends to straiten the flow path
- Steeper slope => even more energy
- Shorter the flow path, same height difference => steeper slope
- On average, length halved
- On average, this increased **energy** twice **[2 X 11.3 = 22.6]**
- On average slope increased twice





Pre-European settlement channel

False colour imagery

Umbango Creek

Credit: Dr Ken Page

CAUSES OF EROSION

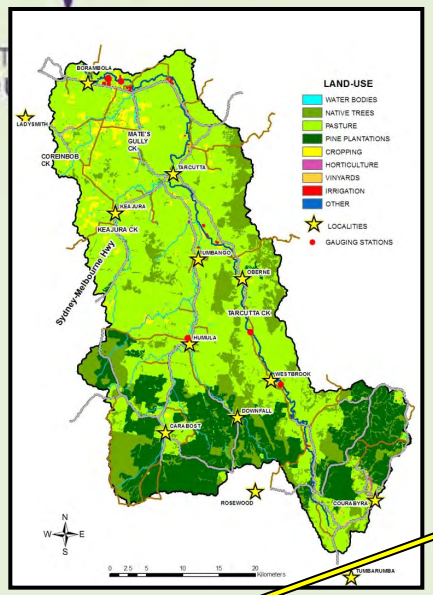
FUTURE FARM INDUSTRIES CRC

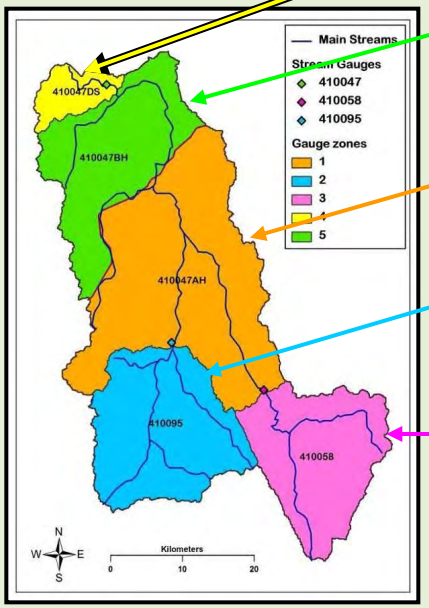
- INDUCED BY EUROPEAN SETTLEMENT:
  - **Sandwich - loss of binding force:**
    - Lack of trees and debris which used to fall into the streams
    - Lack of roots from vegetation
    - All used to act as reinforcement (steel in reinforced concrete)
    - Lack of ground cover to protect the soil
    - Hoofed animals
  - **Widening of the channels and further erosion**

UMBANGO CREEK
Incised reach: deep incision

Photo credit: Dr Ken Page

CAUSES OF EROSION





- Flow increase (1.8 to 11) & associated energy increase (2-25) depend on degree of clearing and perenniality

	% trees	% cropping	Flow* (mm/ year) Native	Current	Flow increase	Energy increase
All	36	6	30	86	2.9	4.1
410047 DS	1	20	2.8	24	8.6	18
410047 BH	3	19	3.6	40	11	25
410047 AH	24	2	18	97	5.5	9.7
410095	69	1	33	68	2.1	2.6
410058	61	1	83	146	1.8	2.1

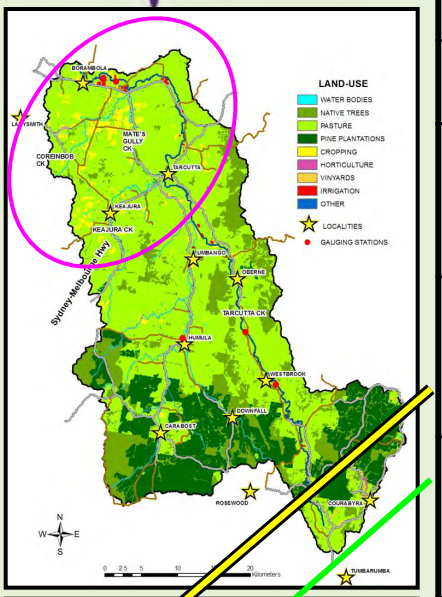
*Amount of rainfall that ends up in the stream

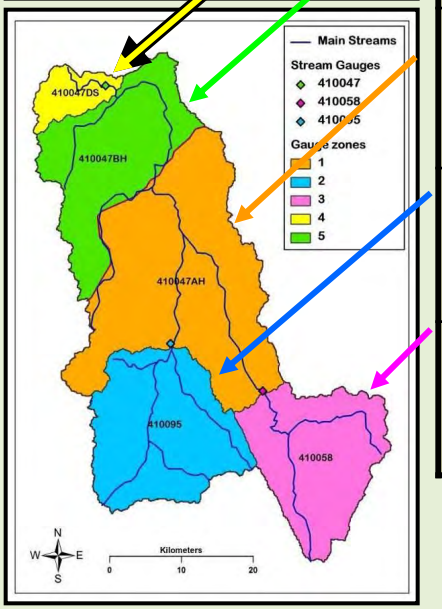
ADVICE: How to reduce erosion?

- **ELIMINATE CAUSES**
  - **Decrease energy**
    - Increase surface roughness
      - No burning to maintain cover
      - Leave dead branches and natural litter
      - Trees and understory around drainage lines and streams
    - Reduce flow – increase perenniality
      - Plant trees: aim at 15%
      - Perennial pasture
  - **Prevent slumps**
    - Vegetation (protection)
    - Reduce floods (increase perenniality)
  - **Improve soil binding forces**
    - Prevent waterlogging and salinity
  - **Sacrificial paddocks** (Droughts)
  - **Less is more** (natural condition)

Well vegetated creek in flood upstream of former swamp above Tarcutta
Photo credit: A Rančić, 5th Sep 2010

ADVICE





Scenario	Current practise	EverGraze (Perennial pastures)				Trees				
Adoption rate		10%	25%	50%	100%	10%	25%	50%	100%	
All	86	83	77	69	54	79	68	53	30	Flow (mm/year)
	1	1.04	1.12	1.25	1.6	1.09	1.26	1.6	2.9	Flow decrease
	1	1.05	1.16	1.34	1.9	1.12	1.37	1.9	4.1	Energy decrease
410047DS	27	22	20	15	8	21	18	12	2.8	Flow (mm/year)
	1	1.07	1.23	1.6	3.1	1.12	1.37	2.0	8.6	Flow decrease
	1	1.10	1.32	1.8	4.6	1.16	1.5	2.5	18	Energy decrease
410047BH	40	36	31	24	14	33	25	16	3.6	Flow (mm/year)
	1	1.11	1.30	1.7	3.0	1.20	1.6	2.5	11	Flow decrease
	1	1.15	1.42	2.0	4.2	1.27	1.8	3.4	25	Energy decrease
410047AH	97	92	84	72	52	86	71	48	18	Flow (mm/year)
	1	1.06	1.15	1.34	1.9	1.13	1.37	2.0	5.5	Flow decrease
	1	1.08	1.21	1.48	2.3	1.17	1.5	2.5	9.7	Energy decrease
410095	68	68	65	61	52	65	59	48	33	Flow (mm/year)
	1	1.00	1.04	1.12	1.30	1.04	1.16	1.4	2.1	Flow decrease
	1	1.00	1,06	1.17	1.42	1.05	1.22	1.6	2.6	Energy decrease
410058	146	145	140	131	115	141	131	114	83	Flow (mm/year)
	1	1.01	1.05	1.11	1.27	1.04	1.12	1.29	1.8	Flow decrease
	1	1.01	1.06	1.15	1.38	1.05	1.16	1.4	2.1	Energy decrease

- Increase in perenniality => flow reduction & energy decrease

FUTURE FARM
INDUSTRIES CRC

SUMMARY

- Erosion is caused mostly by increased energy of flowing water, that resulted mainly from vegetation clearing, due to reduction in surface roughness and increase in flow.
- Increased perenniality reduces surface flow and helps in maintaining year-round cover, therefore reducing the energy of flowing water and erosion.
- Energy increased the most in lowlands, so that is the place with the most opportunity for interventions:
  - Obstacles along water pathway help to slow water down.
  - Understory and trees should be planted wherever possible as a barrier to flow path, to decrease flow speed.
  - Native bushy vegetation along the creeks can help a lot: flood will take out isolated trees, but not the bushy banks.

FUTURE FARM INDUSTRIES CRC

PROFITABLE PERENNIALS™ FOR AUSTRALIAN LANDSCAPES