Quantifying the benefits of environmental flows

Peter Bacon[1] & Tapas Biswas[2]

[1]Woodlands Pty Ltd, Sydney

[2]Australian National University, Canberra

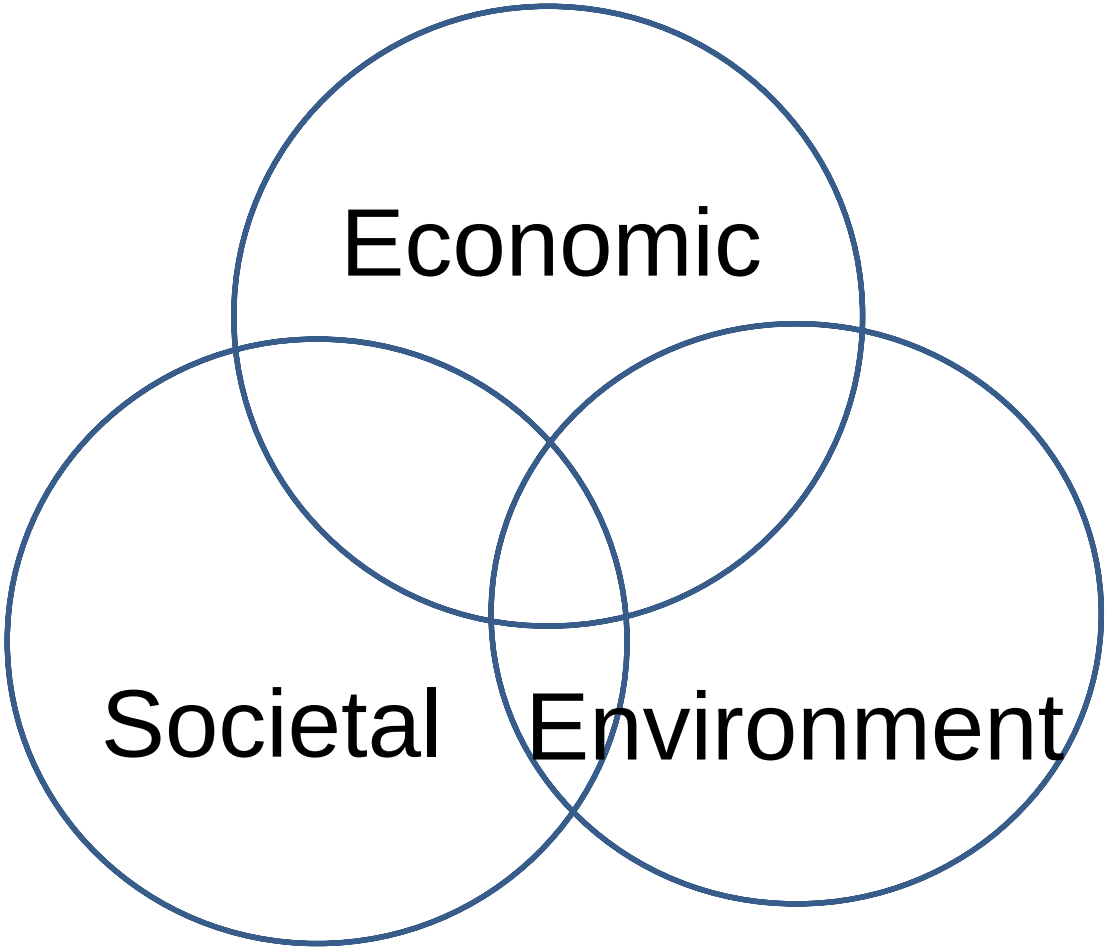
Wagga Soils Workshop, SSA, 2-3 May, 2019

Environmental Flows

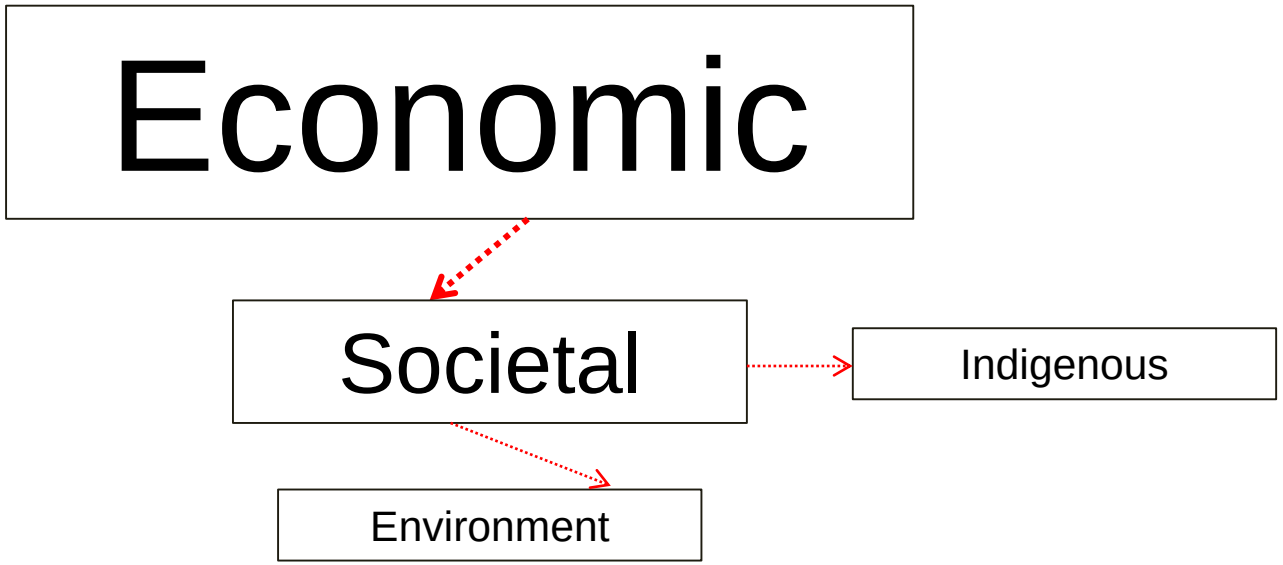
- Protect aquatic ecosystems, reduce aquatic weeds and frequency of algal blooms
- Improve river health
- Improve conditions for native fish, frogs, water birds and river-dependent plants and animals that rely on different flows for migration and breeding
- Protect river condition for recreation such as boating and swimming
- Meet societal obligations-Domestic, stock, Indigenous water (quality) needs.

Role of Environmental Flows

Getting the balance right is critical



The ‘triple’ bottom line as it stands



Is the trickle down approach working?

Scientific evidence >>4,000 GL of water for environmental flows

2,000 GL was the initial allocation.

Australia is now trying to buy back its own water!!

Murray Darling Basin Plan origins

Period	Activity
1860s	Initial water sharing plan among colonies
1895-02	Federation drought >> River Murray Agreement
1960s	Severe drought>> salinity impacts
1990s	Flow analysis demonstrated irrigation >> Major changes in volume and seasonal flow patterns
2007	Water Act (National) aimed at ‘balance’
2012	Basin Plan was to promulgate a healthy, sustainable river system with continued irrigation
2018-19	South Australian Royal Commission found ‘insufficient’ emphasis on the environment. Climate change ignored. Gross maladministration and unlawful actions. Water allotments were driven by politics & $. Science and social license disregarded.
2019	Major fish kills>>water undrinkable, blame game

Compliance and abstraction management

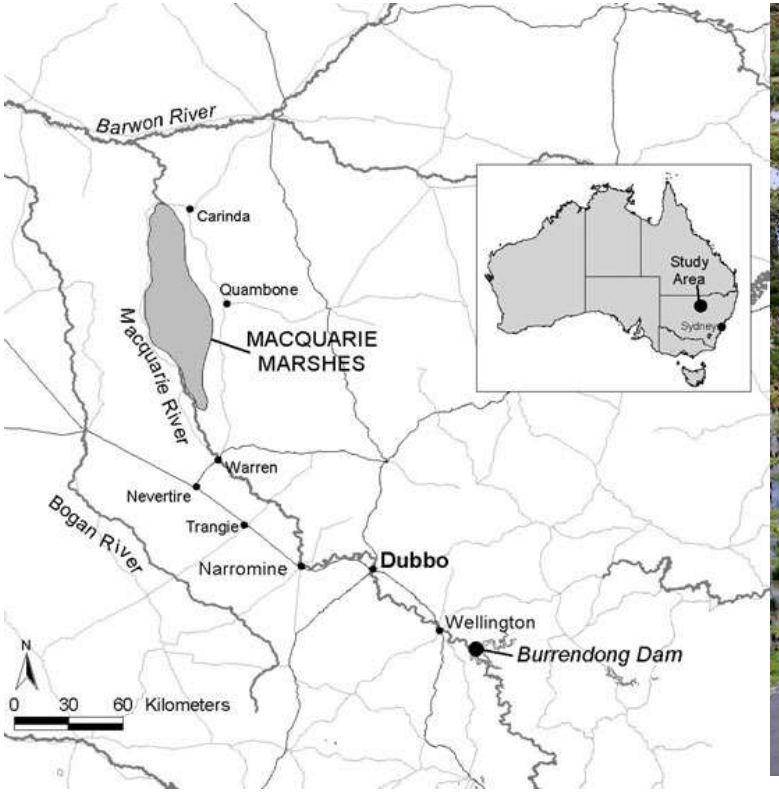
- Irrigators are ‘allowed’ to only draw water under certain conditions, e.g moderate to high flows.

HOWEVER

- Due to insufficient surveillance and enforcement, individuals have been stealing water
    - When is a law a bad law??

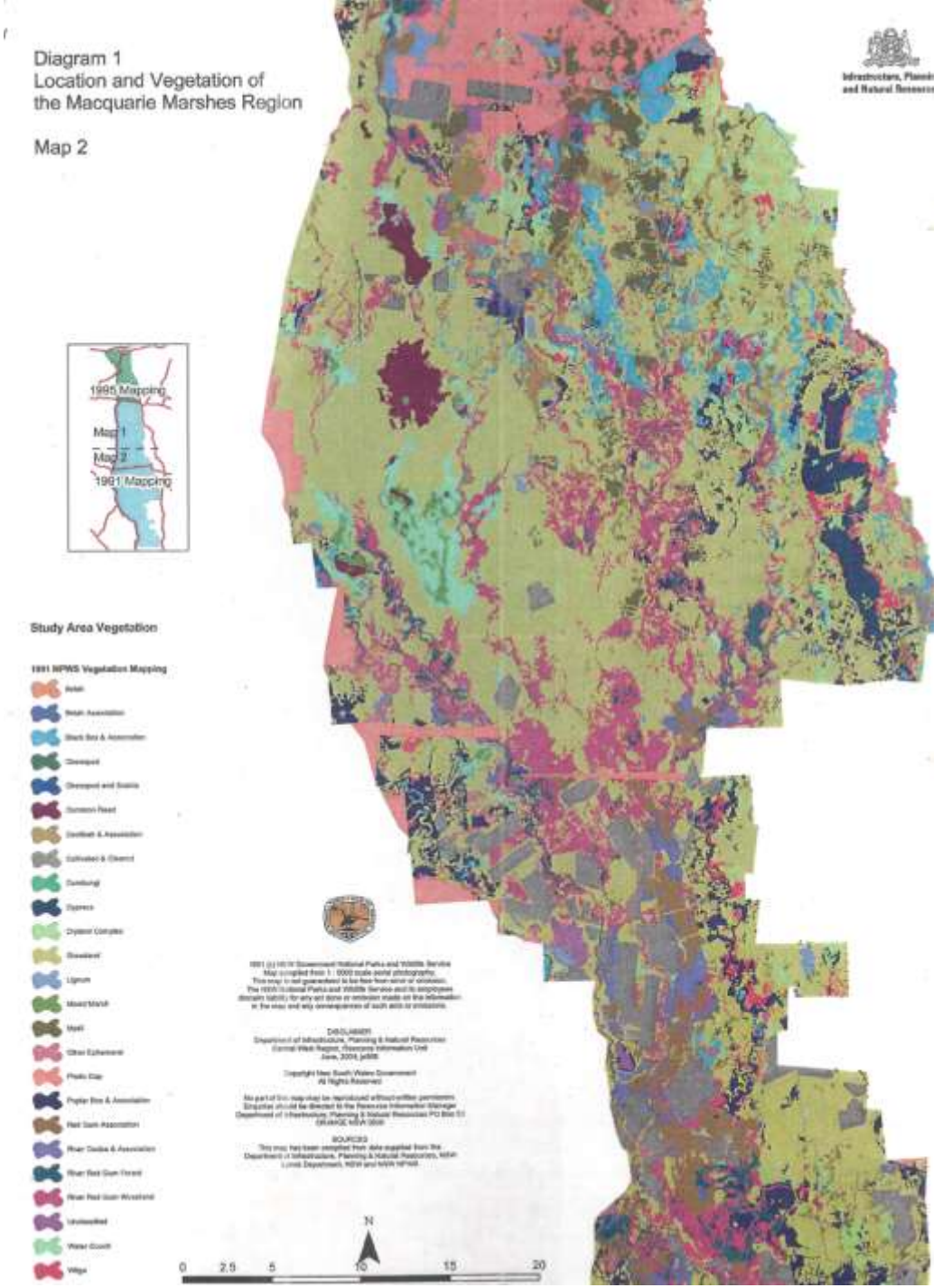
Creative accounting a political issue

Case A: Macquarie Marsh



- A Ramsar listed wetland
- Under threat from water diversion

The vegetation pattern is complex, but ‘driven’ by water availability



What happens if there is no flooding

- Forests typically exist where rainfall is close to 1000 mm/year
- Western NSW riparian forests receive 250 to 450 mm/year
- A ‘forest’ is only possible in western NSW if there is ‘external’ water

River Red Gum is the characteristic overstorey in many inland riparian areas

Diversion of water can kill off wetland vegetation

General view of R block. Note lack of leaves on the trees. Block has not been flooded since 2000. (Photo 77)

Photo taken in 2004

Canopy density in a plot flooded in 2003. (Photo 73)

Comparison between 1994-2004 and 1994-2014 periods

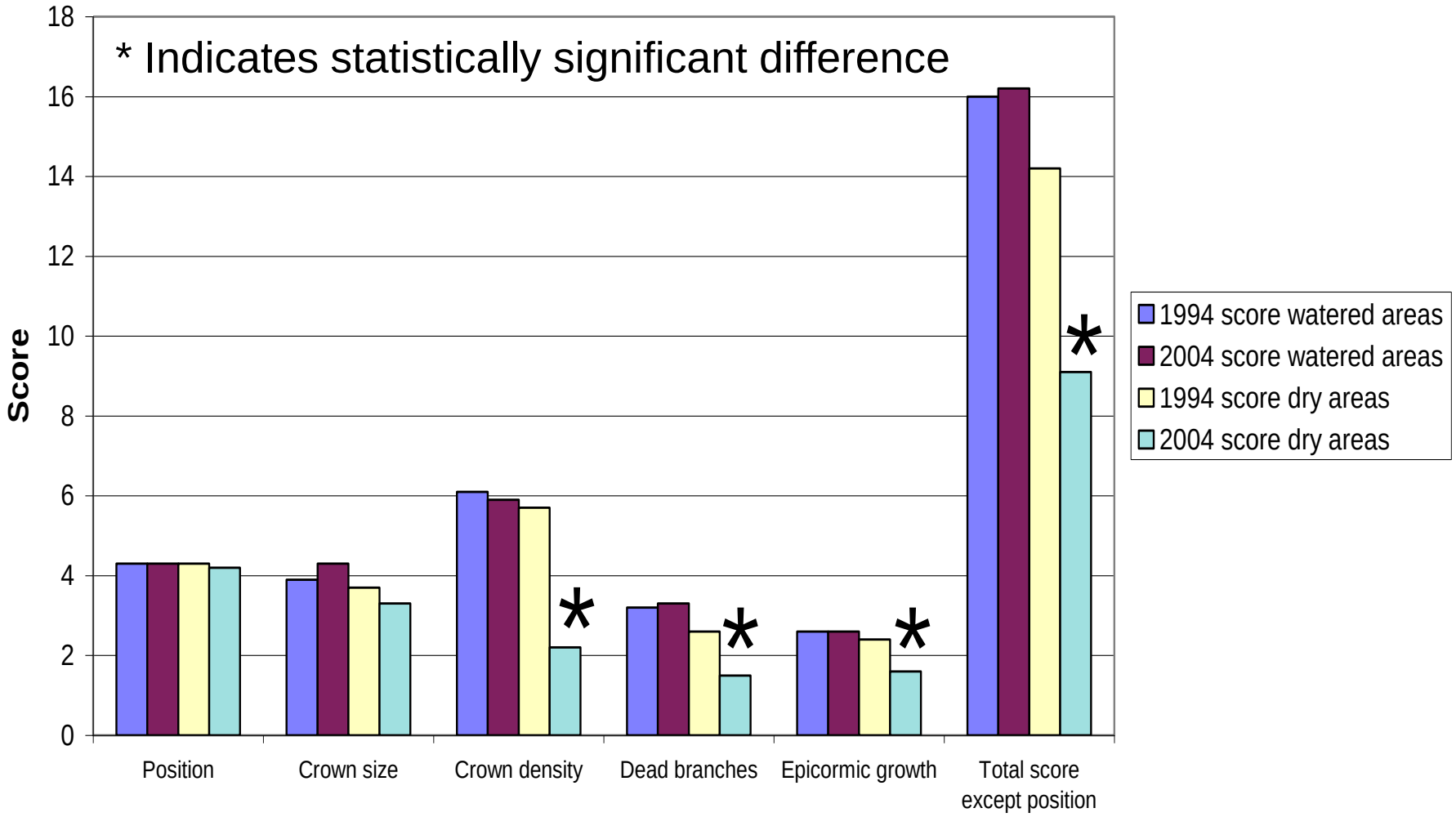
Trees that had received water in spring 2003 have similar health to that recorded a decade ago. By contrast trees that have not received flooding since 2000 have a 61% decline in canopy density as well as significant increases in dead branch frequency and epicormic growth. In some plots over 30% of trees have died over the past decade.

There was no evidence that the decline in tree health was due to factors other than a lack of water.

Catelotti, et al. (2015), found more than half the trees reported as ‘healthy’ had died by 2011.

Tree death was directly related to lack of flooding in the past 5 years.

Tree health score for wet and dry sites in 1994/5 and 2004



Case B: Gwydir Wetlands

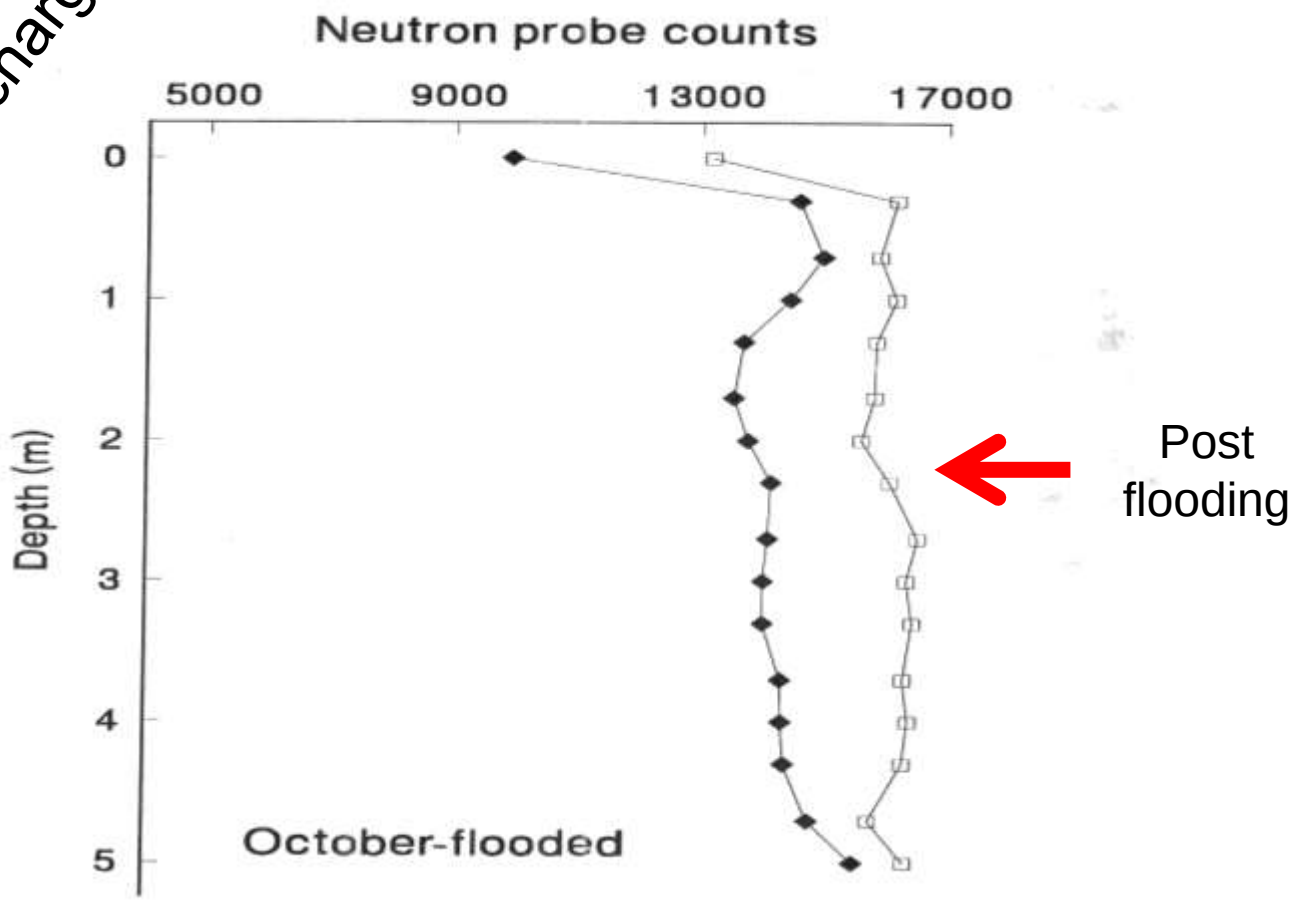
Gwydir Wetlands, same spot 2003

What happens to a site when it floods?

- Is there a measurable ‘benefit’?
- It obviously depends on what you mean by benefit!!!!!

Impact of flooding on soil water content (expressed as counts) to 5m deep

(up to 1500 mm of recharge)



Impact of flooding on water sources

	HEALTHY	STRESSED	SIGN
Water table depth (m)	2.9	3.2	N.S.
Groundwater salinity (dSm)	29	24	N.S.
% of water derived from groundwater	43	62	*
Tree water use (l hr^{-1})	5.3	3.4	*
Groundwater use (l hr^{-1})	2.1	2.2	N.S.
Surface water use (l hr^{-1})	3.2	1.2	*

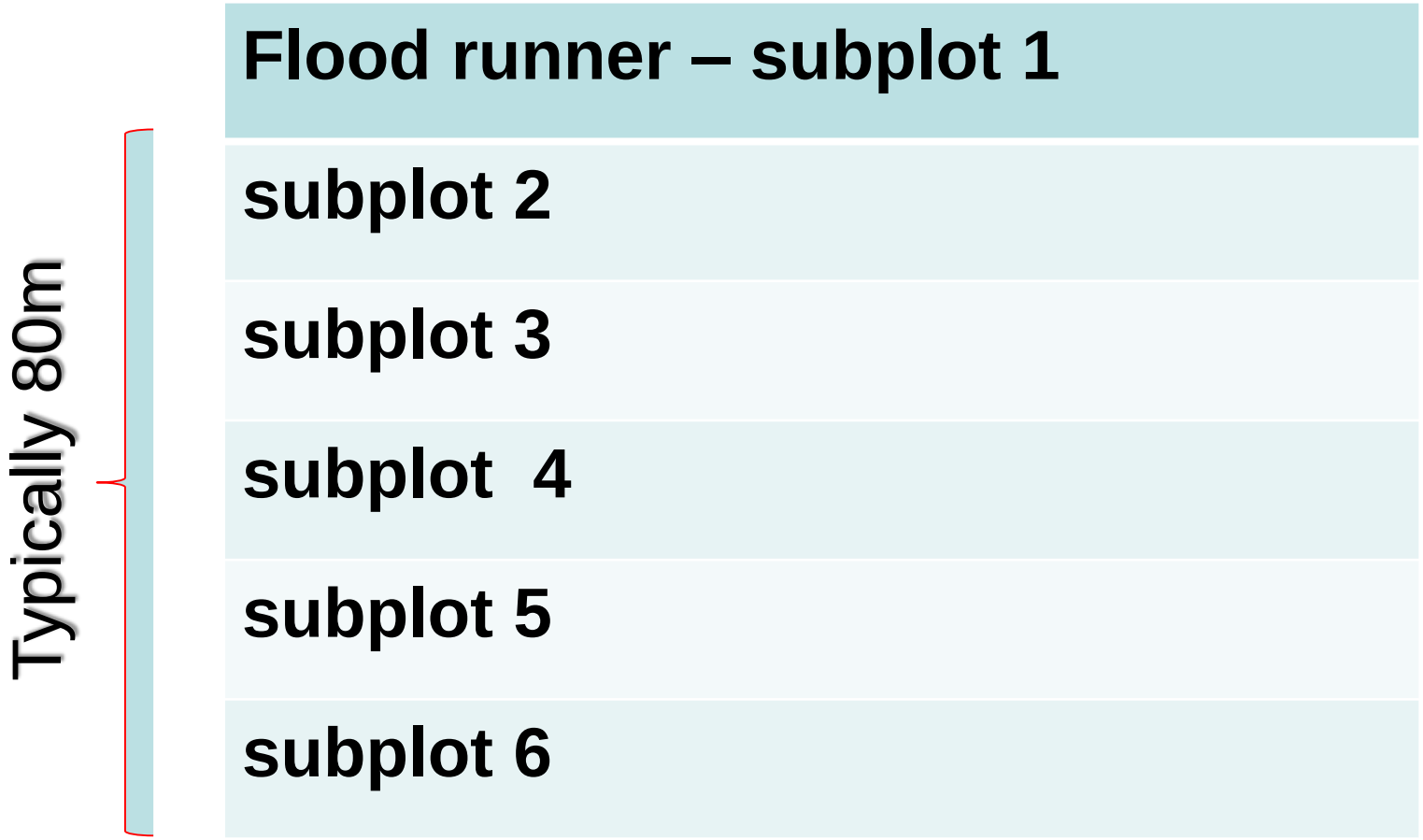
Conclusions re: River Red Gum survival in the Macquarie Marsh

- RRG survival is critically dependant on flooding.
- Over half of trees that were healthy in 1993 died by 2011.
- Death was correlated with lack of flooding in the previous 5 years.
- Healthy trees occurred in areas where at least 5 floods occurred in the previous decade.

CASE C: Millewa Forest experiment (1993 to 2001)

- 12 plots each with natural flood runner along one side [Plots = 0.5 to 1 ha].
- Each plot ‘divided’ into 6 subplots parallel to the flood runner.
- One subplot in the flood runner, the furthest one up to 80 m away.
- Weirs installed to control floods.
- No flood compared with annual spring, annual summer and spring + summer.
- Flood duration 3 to 8 weeks

The plot layout



RESULTS

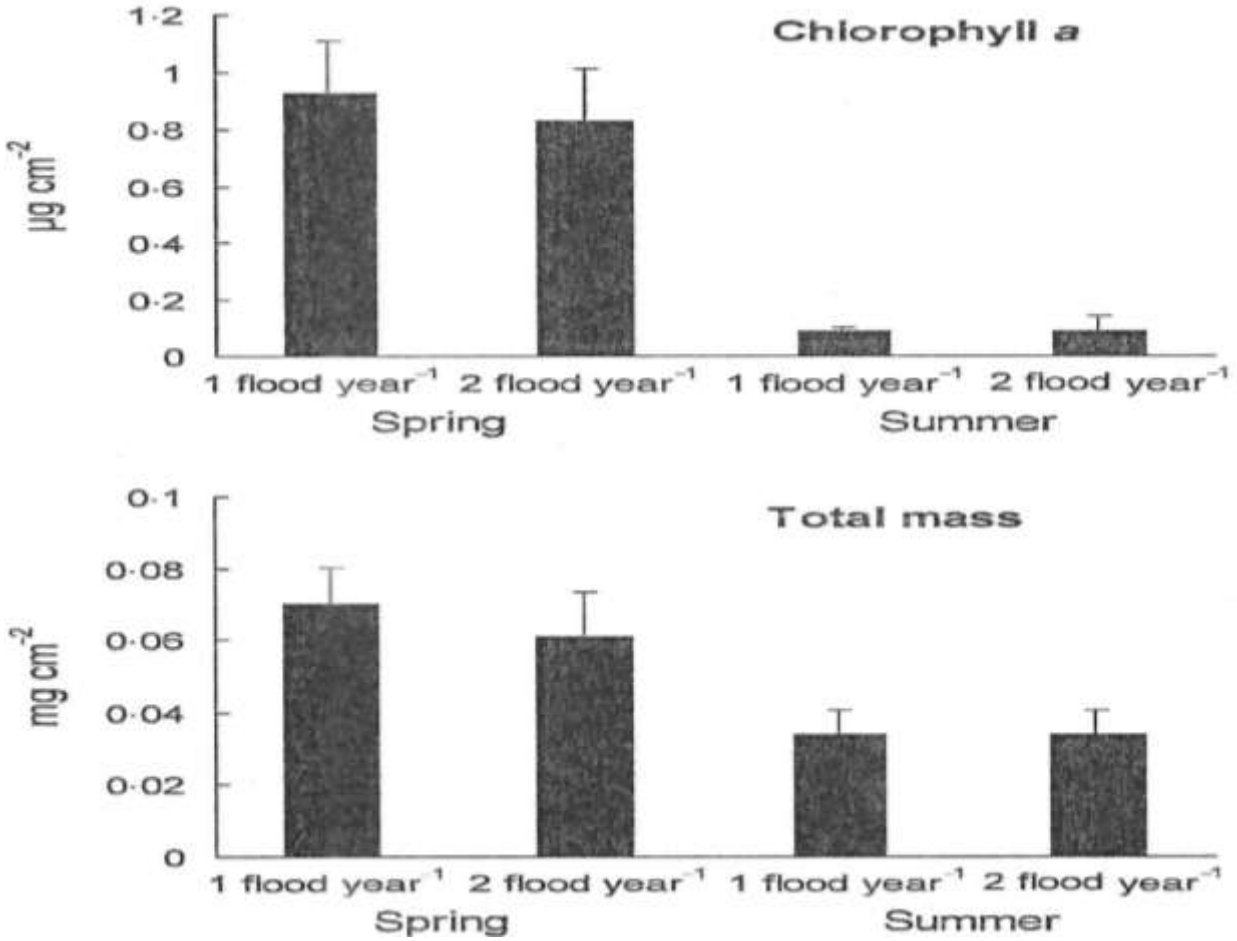
- Water penetration to 1.3 to 6 m deep
- Horizontal migration zero to 38 m (sandy horizons at depth
- Trees in plots underlain by a shallow aquifer had minimal flood response. -GDE??).
- Elsewhere, flooding resulted in a statistically significant increase in RRG XPP from −0.45 to −0.10 MPa.
- The effect of flooding on XPP extended between 22.5 and 37.5 m from the floodwater.

FISH kill in Summer

(100% mortality of yellow belly fingerlings within a few minutes of release)

(Peter Gehrke, NSW Fisheries)

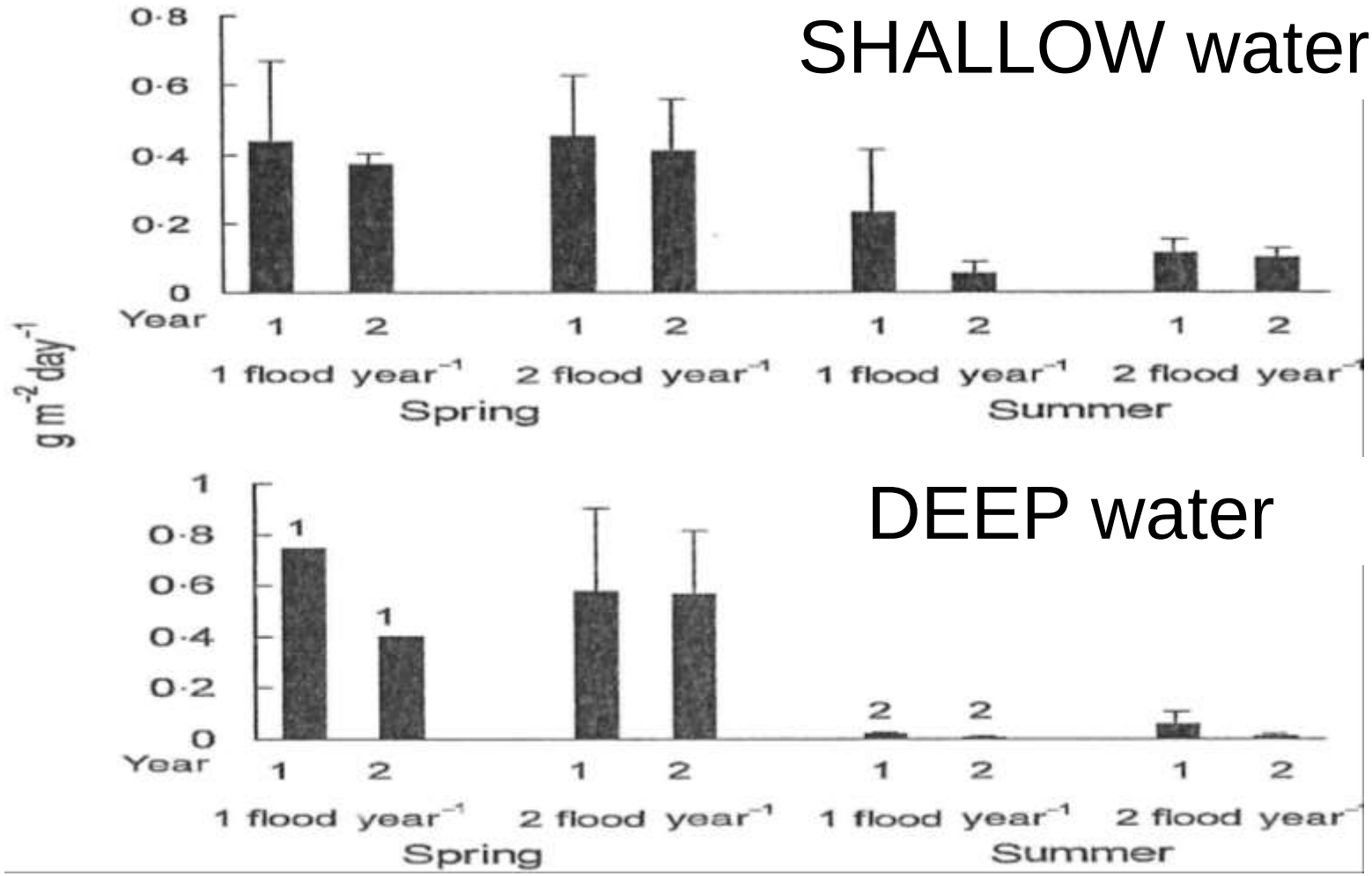
Primary productivity in Millewa SF



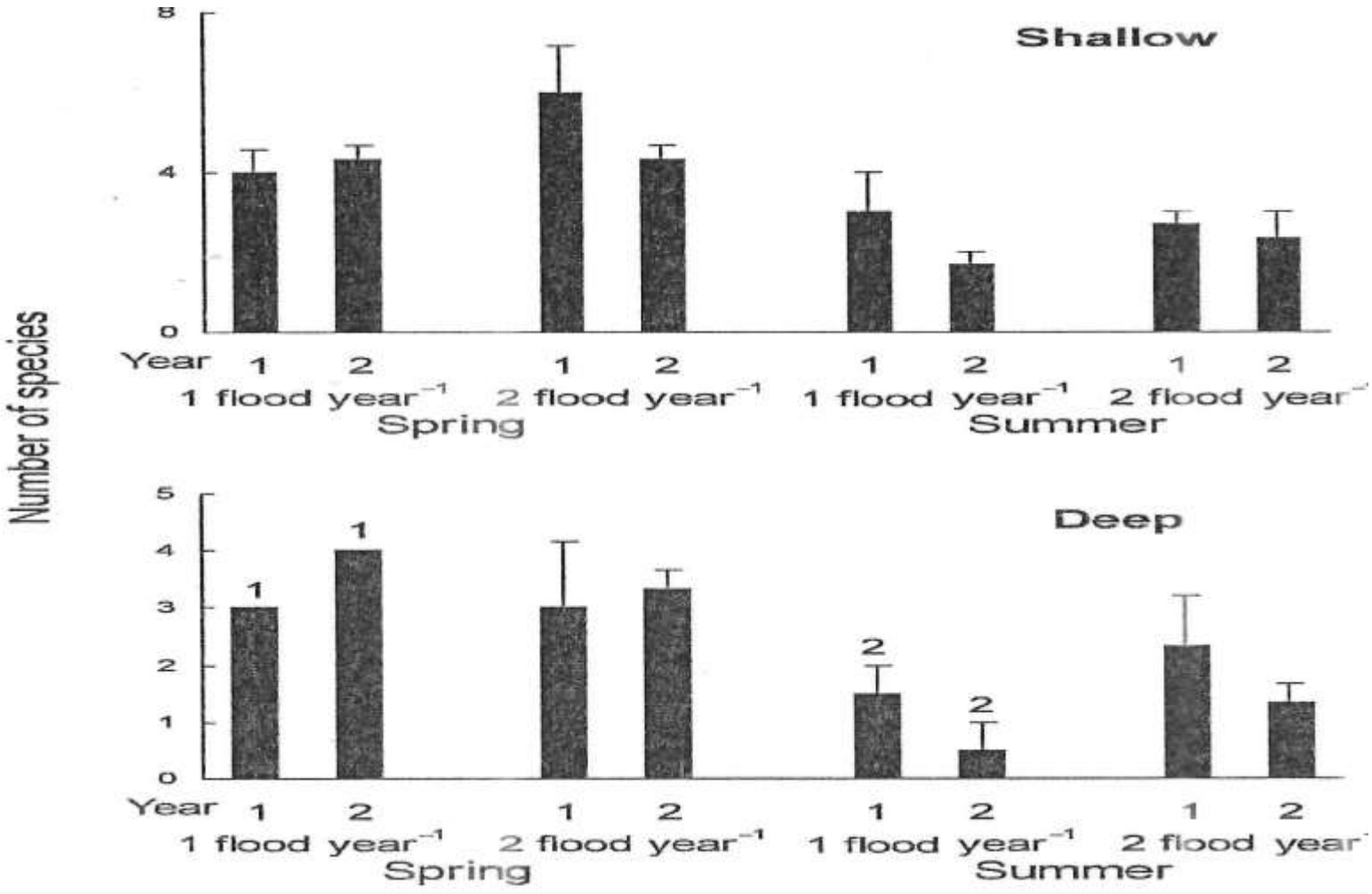
After Robertson et al, 2001.

Chlorophyll-*a* (ug cm^{-2}) and total dry wt of film biomass (mg cm^{-2}) with change in flood year 1 and 2.

Aquatic macrophyte production rate in shallow and deep water during spring and summer flooding



Impact of spring or summer flooding with shallow and deep water on number of aquatic macrophytes



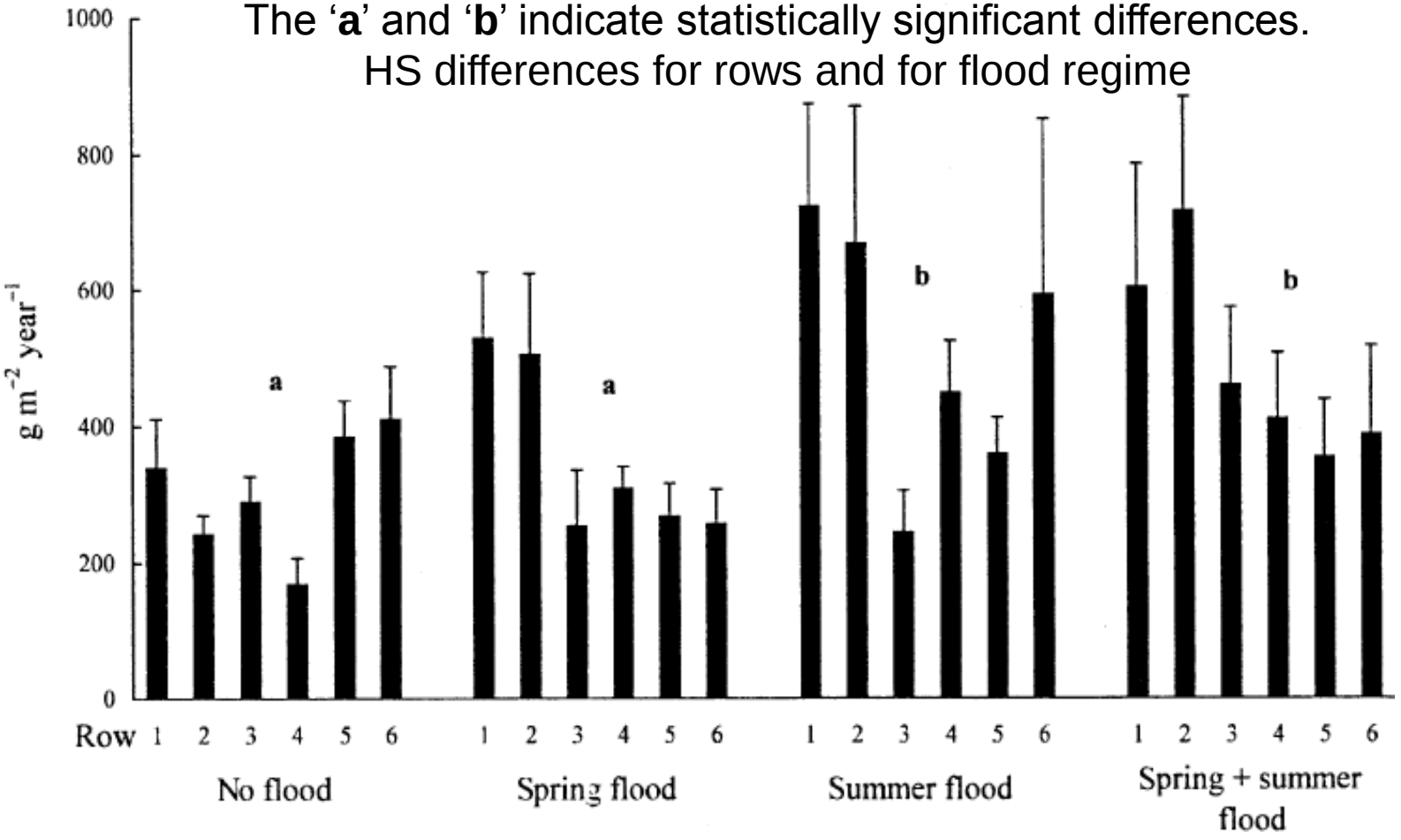
After Robertson et al, 2001.

Tree responses

- Leaf size (cm sq) 11.0, 12.2, 13.2 with zero, 1 or 2 floods/year.
- Trees in runner, Trees 8m away, and Trees 38 m away = 12.9, 13.6 and 9.9 cm sq average leaf area
- Tree relative growth rate increased up to 23m from the water edge.

Annual RRG wood production in each combination of ‘row’ and flood frequency

The ‘**a**’ and ‘**b**’ indicate statistically significant differences.
HS differences for rows and for flood regime



Conclusions

KEY MESSAGE: Flooding is essential. The environmental benefit is statistically verified.

- Environmental flows recharge soil moisture (by up to 1500 mm).
- Environmental flows result in statistically significant increases in primary productivity.
- Half the healthy Macquarie marsh RRG in 1993 died by 2011 without flooding for 5 years.
- RRG response to flooding extended up to 38 m from water edge in Millewa forest- A GDE??
- Response to summer flooding depended on species and water depth.