20th International
RIVER SYMPOSIUM
and Environmental Flows Conference

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Where have all the flowers gone?

Using phenology to determine key timing for environmental watering

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BRISBANE, AUSTRALIA | 18 - 20 SEPTEMBER 2017

MANAGED BY INTERNATIONAL RiverFoundation

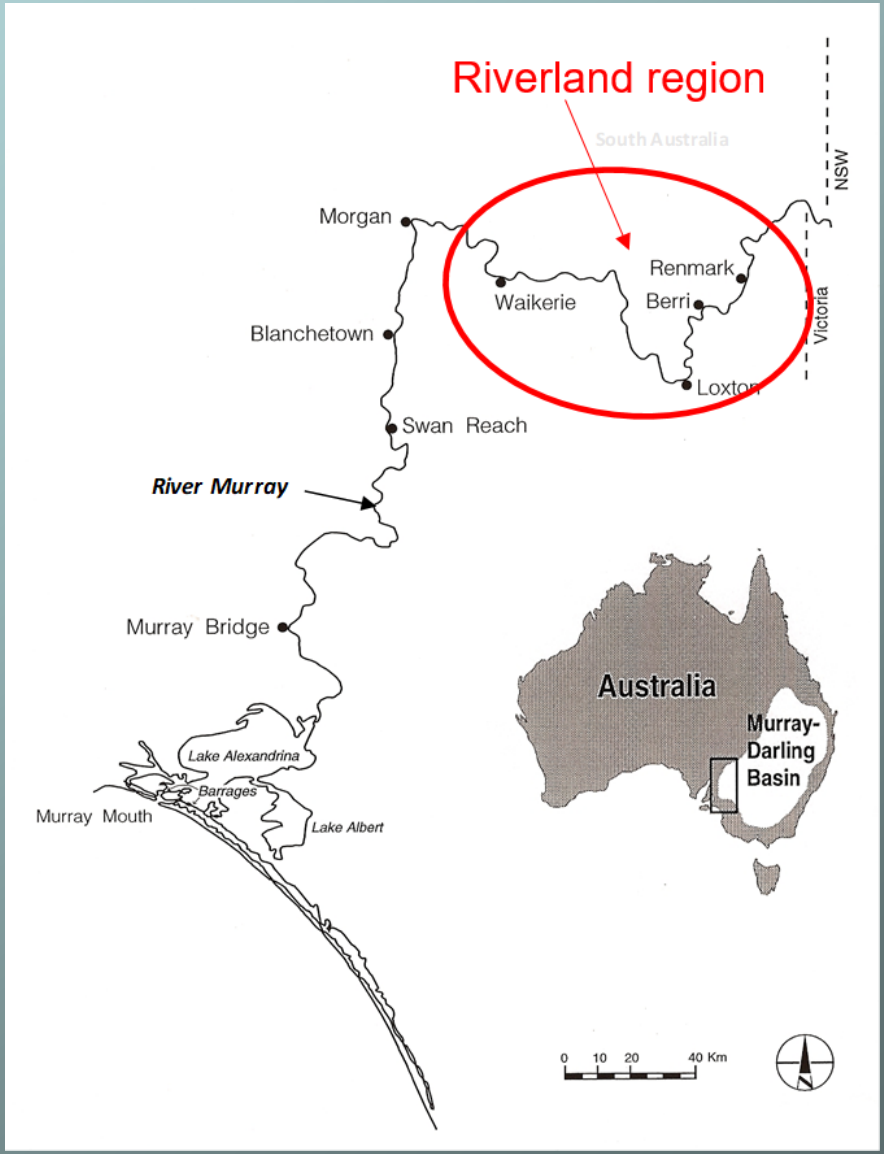
Lower Murray Valley

Effects of river regulation, upstream dams & extraction since 1920s:

- no small floods
- fewer, shorter, later medium-large floods
- drier, smaller floodplain

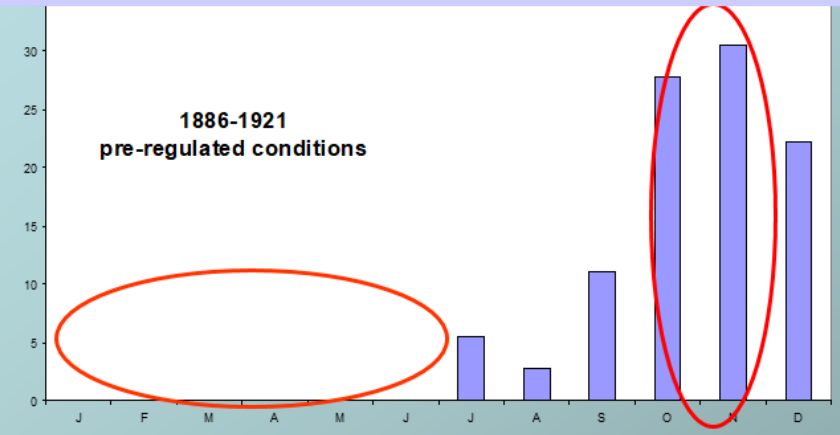
Millenium Drought 2000-2010

- no over-bank flows for 14 years
- extensive death & decline in floodplain woodlands & shrublands
- Lower Lakes below sea level

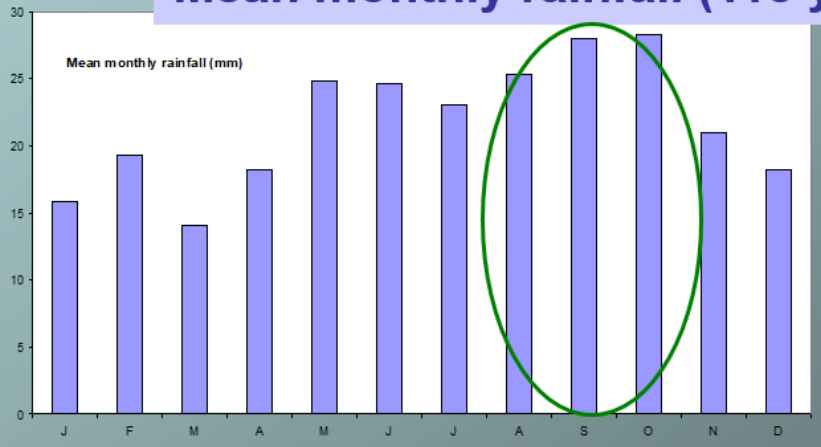


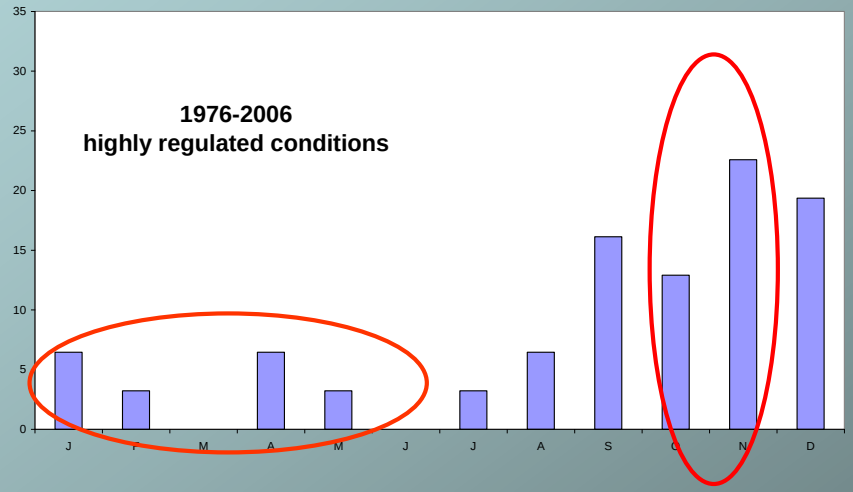
Changes in historic conditions

seasonality of peak flows (% by month)



Mean monthly rainfall (118 y)





- fewer peaks in spring
- later peaks into summer (hotter, drier conditions)
- since regulation, peaks occurring Jan-Jun period

Effective Use of Limited Environmental Water to halt / reverse Decline

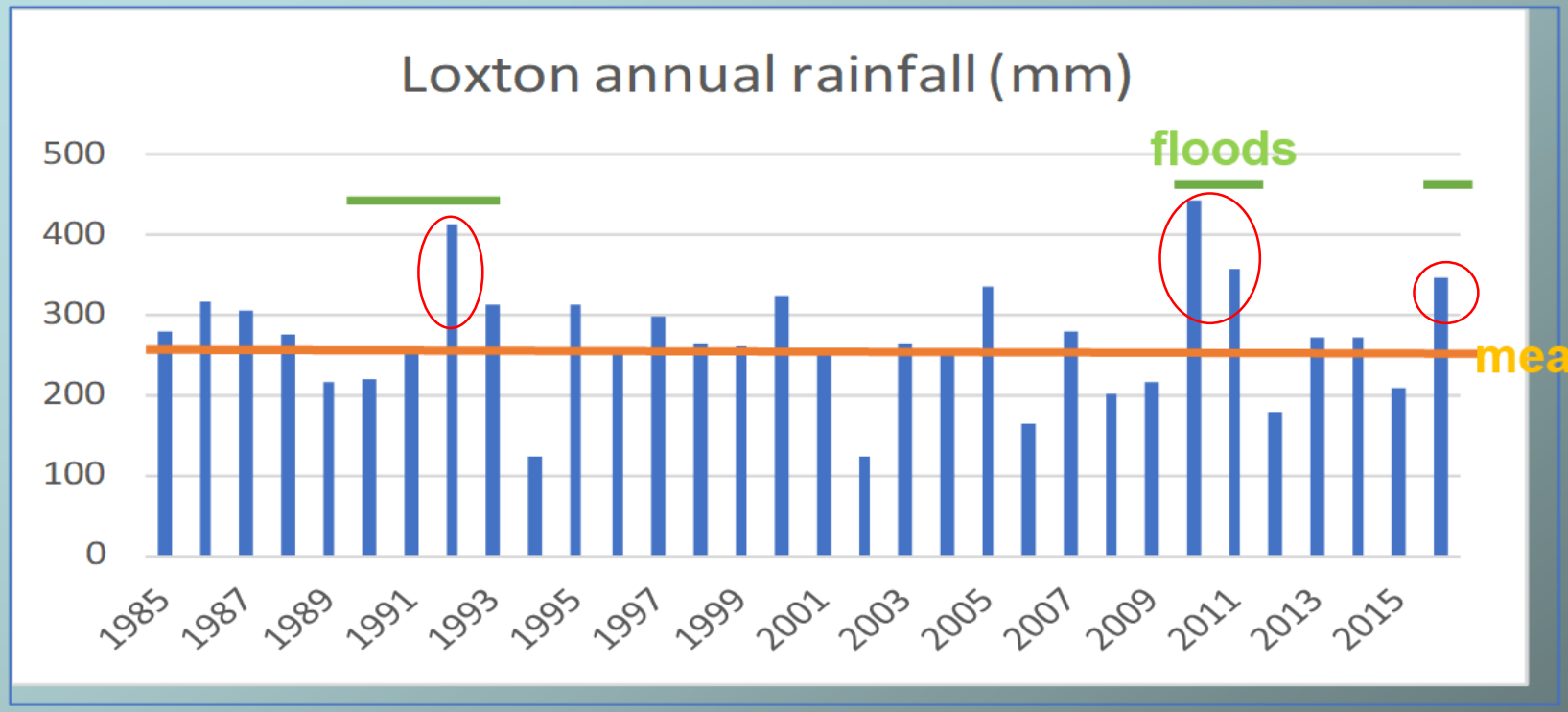
- target stressed dominant perennial floodplain species -- eucalypts (red gum & black box) & lignum
- aim to coincide with seed shed from aerial seed banks
- seed shed 12 months after flowering in eucalypts, within 4 weeks for lignum
- maintain soil moisture to match phenological timing

Natural Phenological Patterns

Data 2004-2008 (drought conditions):

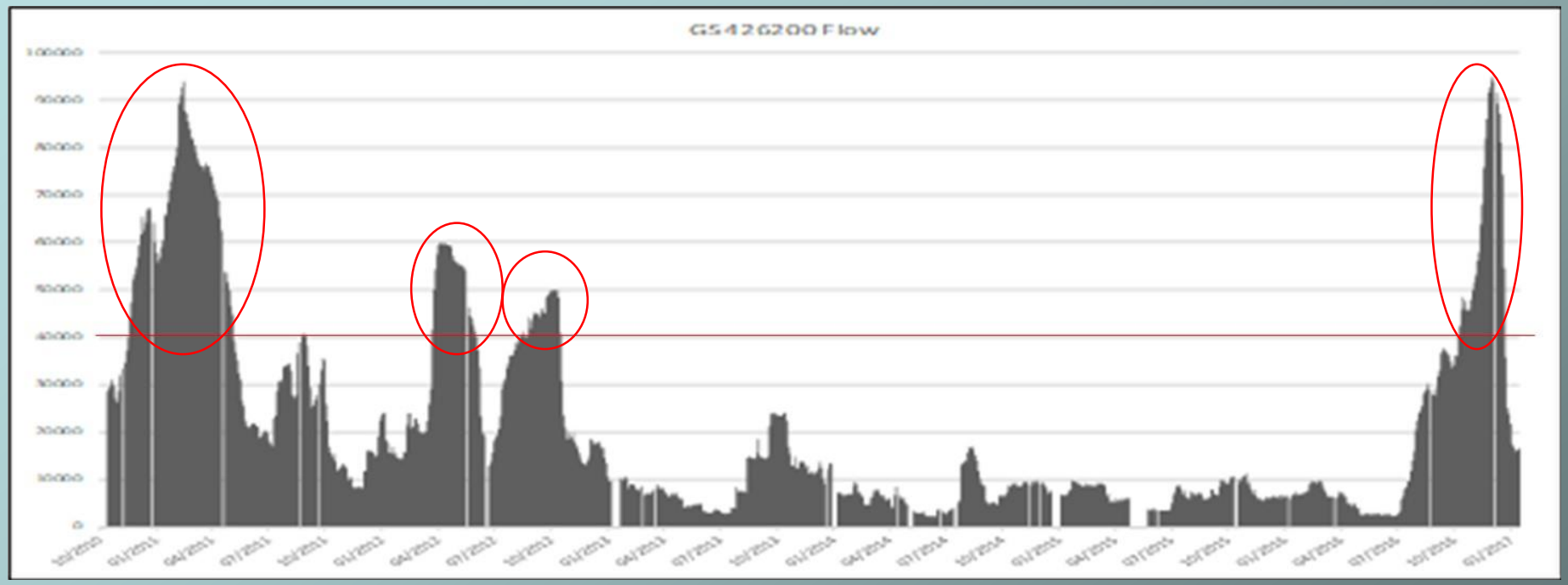
- Biennial cycle in floodplain eucalypts, seed shed appears to coincide with highest chance of soil moisture (flood + rain)
- 2 years from buds to seed, individual trees on opposite cycles, so seed avail every year from different trees
- Red Gum flower 3-4 weeks in summer months (Nov-Mar)
- Black Box mostly flower in summer (Dec-Feb), few in winter (May-Jul)
- Lignum opportunistic, responded to heavy spring rain (Oct)

Rainfall is important factor



Successful recruitment (survival to reproductive age) correlated with medium floods (>40,000 ML/d for red gum, > 80,000 ML/d for black box) & above average rainfall (>300mm) (George *et al.* 2005)

Drought Broken -- Floods 2010-12



Flows at the South Australian border Oct 2010 to Feb 2017:

- overbank flows above 40,000 ML/d (*red line*)
- peak of 93,872 ML/d in Feb 2011 (170 d + 71 d 2012 overbank)
- no overbank flows Oct 2012 to Oct 2016
- peak of 94,865 ML/d in Dec 2016 (75 d overbank, rapid recession)

The Black Box 2011 germination story

- Black Box is 2nd major eucalypt of Lower Murray floodplain woodlands, typically at higher elevations, lower flood frequencies, outer edge of floodplain, more salt- & drought-tolerant, compared to red gum
- 2010-2012 flood sequence led to mass black box germination at medium elevations
- late flood peaks (Feb & Apr), extended duration into cooler months, very high rate of survival of seedlings
- lack of recruitment from flood events in 1970s & 1990s, last extensive recruitment was from 1955-56 floods
- Black Box recruitment at $^{1}/_{3}$ rate required to replace existing communities (George *et al.* 2005)

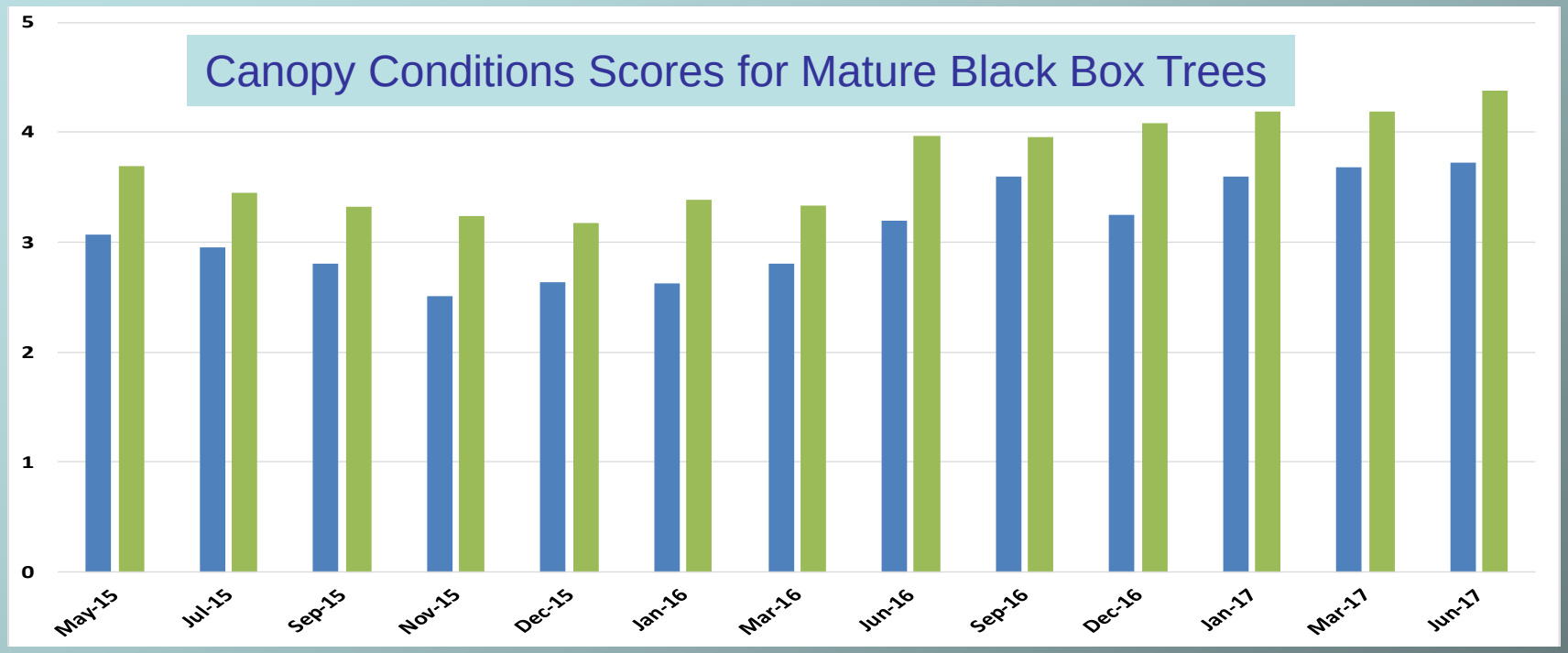
ack box germination seen
ed habitats with sustained
moisture, eg above weirs

the 2011 seedlings are very special!!

Environmental Watering to sustain Black Box seedlings

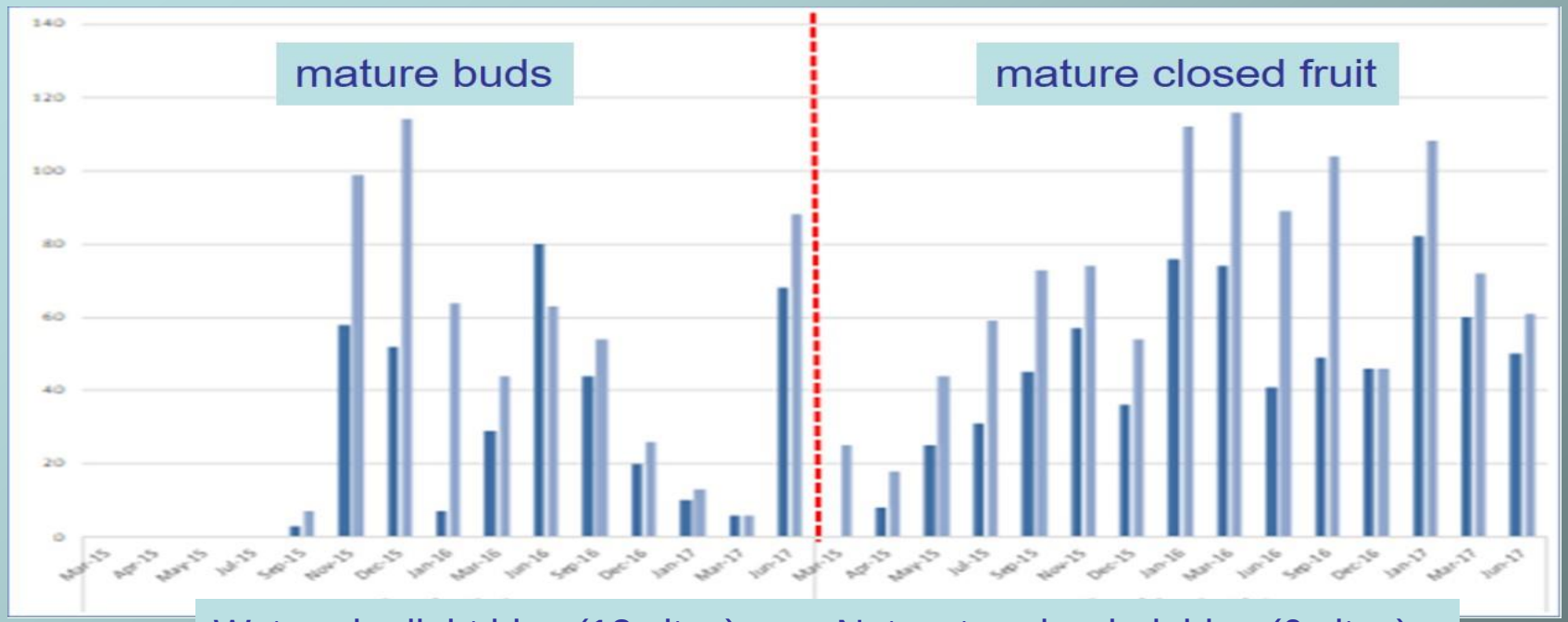
Black Box seedlings near Loxton watered summer 2013-14
early response May 2014 seedlings <=1.2 m tall (*left*);
watered again summer 2014-15;
March 2017, following flooding Dec 2017, seedlings <=3.5 m tall (*right*)

Environmental Watering makes a Difference …



Watered = green (12 sites)
Not watered = blue (6 sites)

Environmental Watering makes a Difference . . .



Watered = light blue (12 sites) Not watered = dark blue (6 sites)

Change in Flowering Patterns

Blue = buds
Red = flowers
Green = fruit

- first year results confirmed expected single biennial cycle, most flowering in summer
- <u>BUT</u> in June 2016 (= winter), ~70% mature Black Box across Riverland region in vigorous flower!
- some trees flowered 2 or 3 times from same bud crop (Jun, Sep, Dec), similar observed in Mt Lofty ranges for other eucs
- as canopy condition improved, trees carrying dual crops, developed two biennial opposite cycles on same tree!

Is it change or variability?

Lots of questions:

- a return to ‘normal’ (recovery from drought stress)?
- Is ‘normal’ pattern dual opposite biennial crops with seed on every tree every year?
- Is this climate change effect (later floods, summer rains, higher humidity)?
- previous data (drought conditions) showed trees did not alter timing of crops or seed shed, greater crop volumes in response to available water
- current data (healthy conditions) show trees with shorter cycles & multiple seed shed – change or variability?
- EWRs evolved with regime over centuries but predicted future reduced flows can’t provide minimum needed

Need more data!!

Adding environmental water for most effective outcomes

healthy, 9,000 seeds m^{-2}

dry, stressed, 900 seeds m^{-2}

watered, recovering, dense buds

Water to maintain soil moisture, to support development & retention of buds, flowers, fruit crops; to coincide with seed shed to trigger germination; to maintain canopy condition in mature trees; to prime wetlands in late autumn/early winter

Acknowledgements

- Thanks to the late Assoc Prof Keith Walker for invaluable advice on preliminary analysis of results for this project, and Dr Fiona Paton of the University of Adelaide for constructive comments on analysis of data and results

- This work was supported as part of the project *Ecological Responses to Environmental Watering in the South Australian River Murray Valley,* assessing the benefits of salinity interception schemes on floodplain vegetation, coordinated by Australian Water Environments Mar 2015 --Jun 2017

- Water for the environmental watering projects studied here was provided through annual allocations of water from the Commonwealth Environmental Water Office to Nature Foundation SA

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