Department of Environment and Natural Resources

Cropping sustainability & erosion risk under climate change

Statewide modelling project

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(Presenter: Craig Liddicoat)

Government of South Australia

Acknowledgements

- Funding: State NRM Program & DENR
- Vision: DWLBC (now DENR) & SARDI following earlier work: DENR > “Regional Climate Change Decision Framework”
- Australian Govt (DAFF)
- Bertram Ostendorf (Uni of Adelaide)
- “State Land and Soil Information Framework” (DENR)
- NY NRM Board – support for pilot
- Tim Herrmann, Giles Forward (DENR) & Rural Solutions SA regional consultants

Government of South Australia
Department of Environment and Natural Resources

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

RURAL SOLUTIONS SA

Aims of the project

To explore key questions ....

- How might a warming, drying climate impact on cereal cropping, in particular:
  - (i) **wheat grain yields**
  - (ii) **crop biomass to protect soils from erosion**
- What is the influence of soil type and regional climate?
- What are potential implications for land use/ management?

- How can APSIM, in combination with available spatial data, be used to provide indicators of vulnerability of cropping systems to climate change?

What is new about this work?

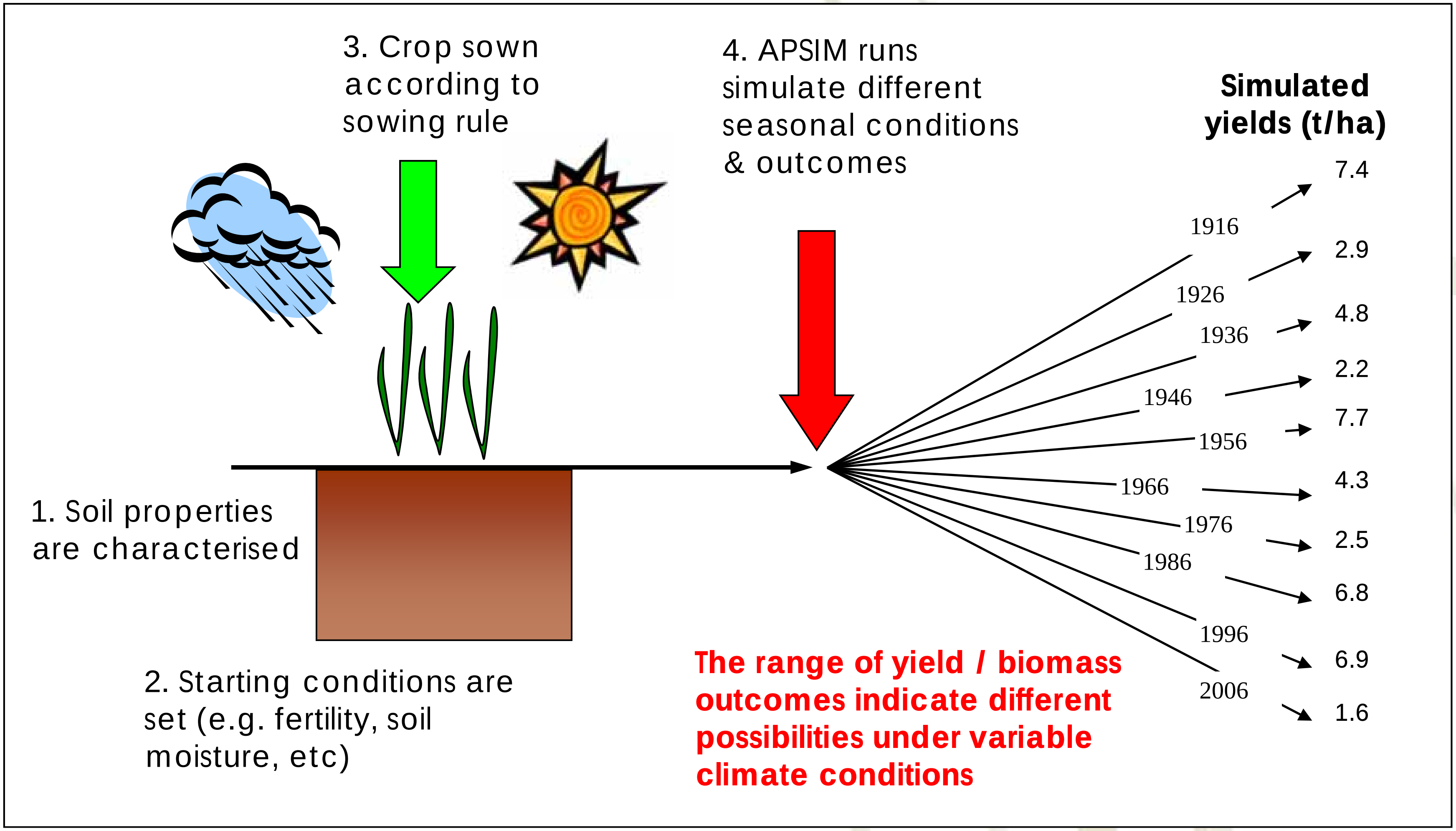
- APSIM has been used before in spatial crop yield modelling
- This study:
  - Links (i) production and (ii) sustainable land management
  - Makes greater use of our State's soil and land spatial data (including sub-dominant soil types)
  - Links point-based APSIM to spatial data (soils, climate zones) via a matrix of ***"modelling soil types"*** and average climate zones
  - Examines changes in the frequency and severity of erosion risk under climate change

Requirements for modelling

1. APSIM crop simulation tool
2. Upscaling method
3. Soil and Land information
4. Climate information
   (including climate change scenarios)
5. Erosion risk assessment
6. Map production
7. (Review and refinement)

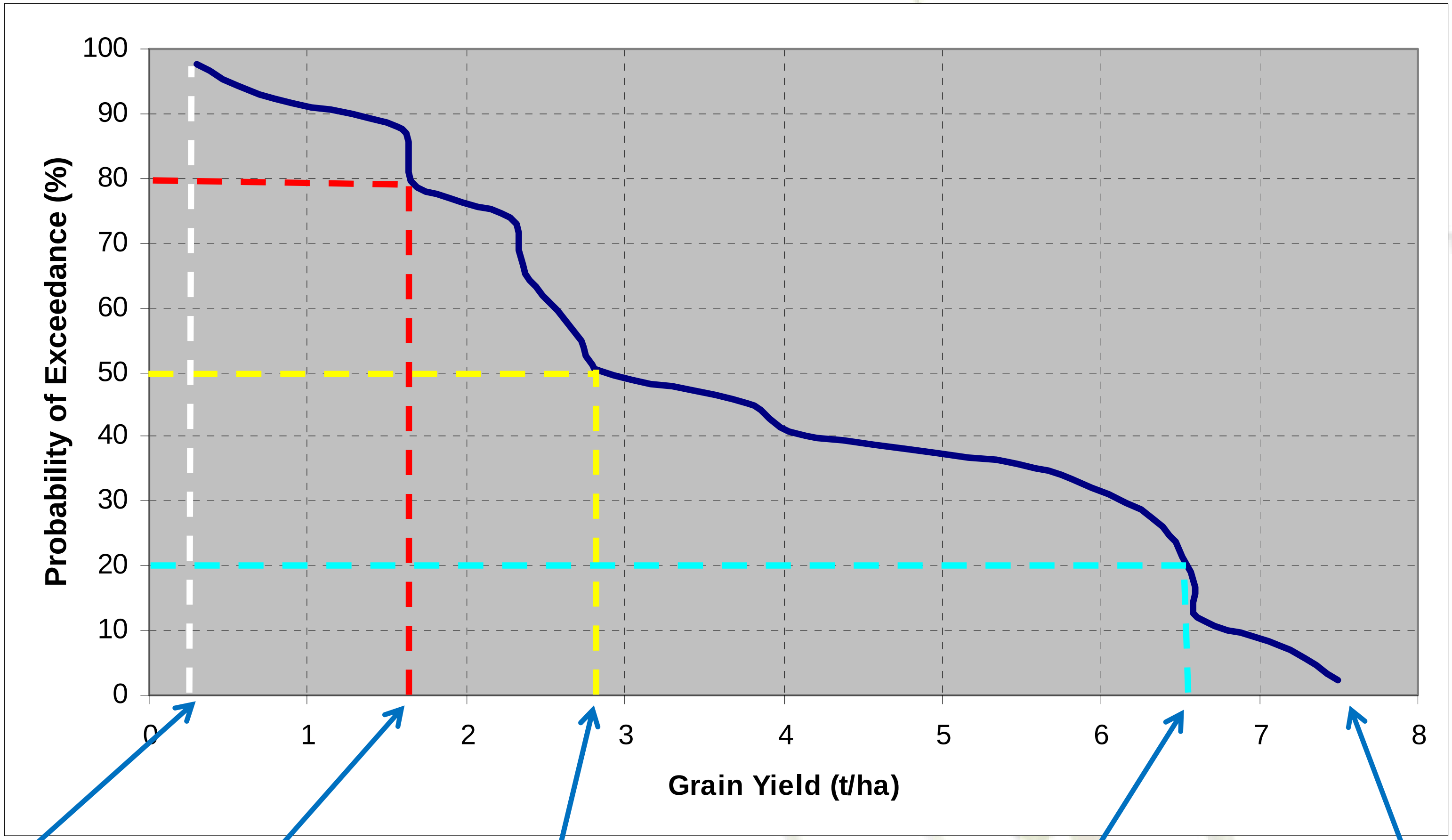
APSIM

(Agricultural Production Systems Simulator)



Adapted from T McLelland 2009 pers. comm.

APSIM



Worst on record

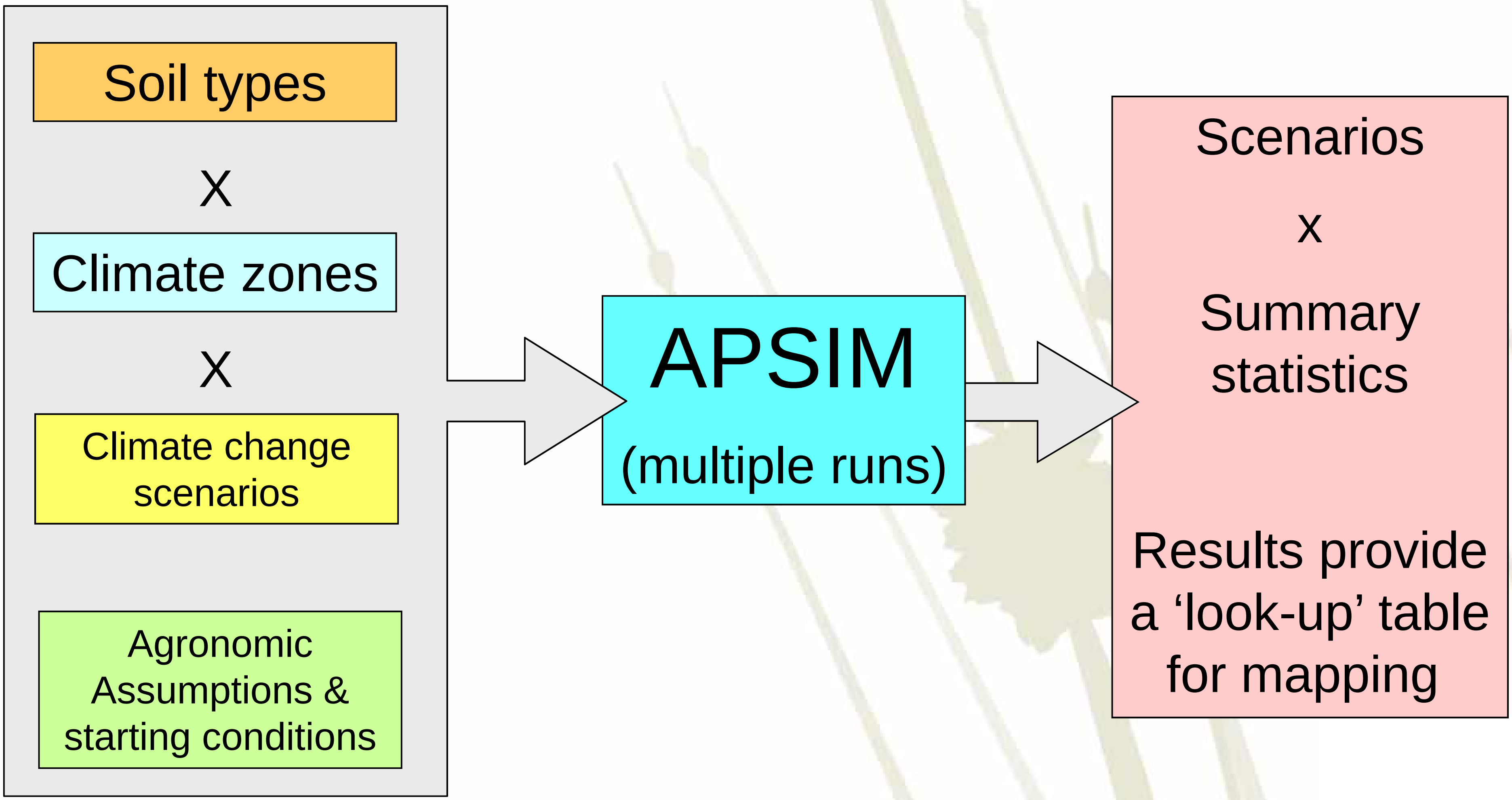
20th Percentile

50th Percentile

80th Percentile

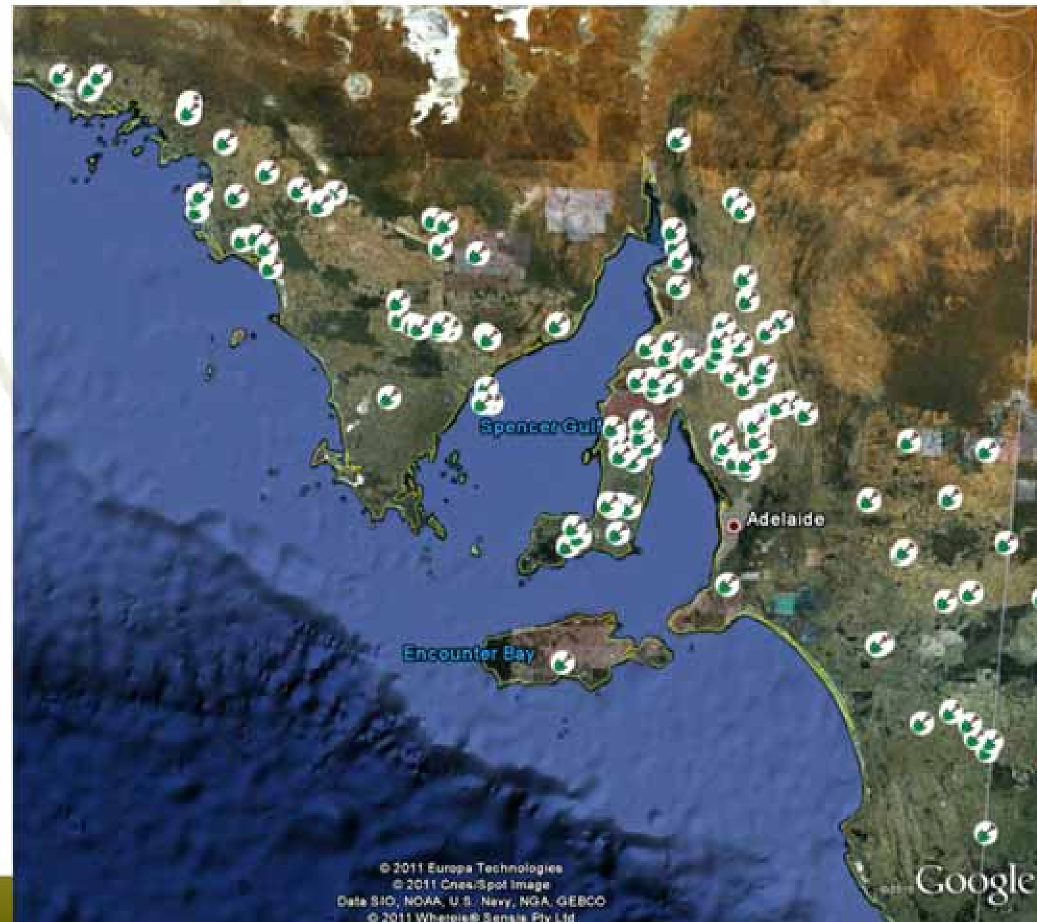
Best on record

Upscaling method

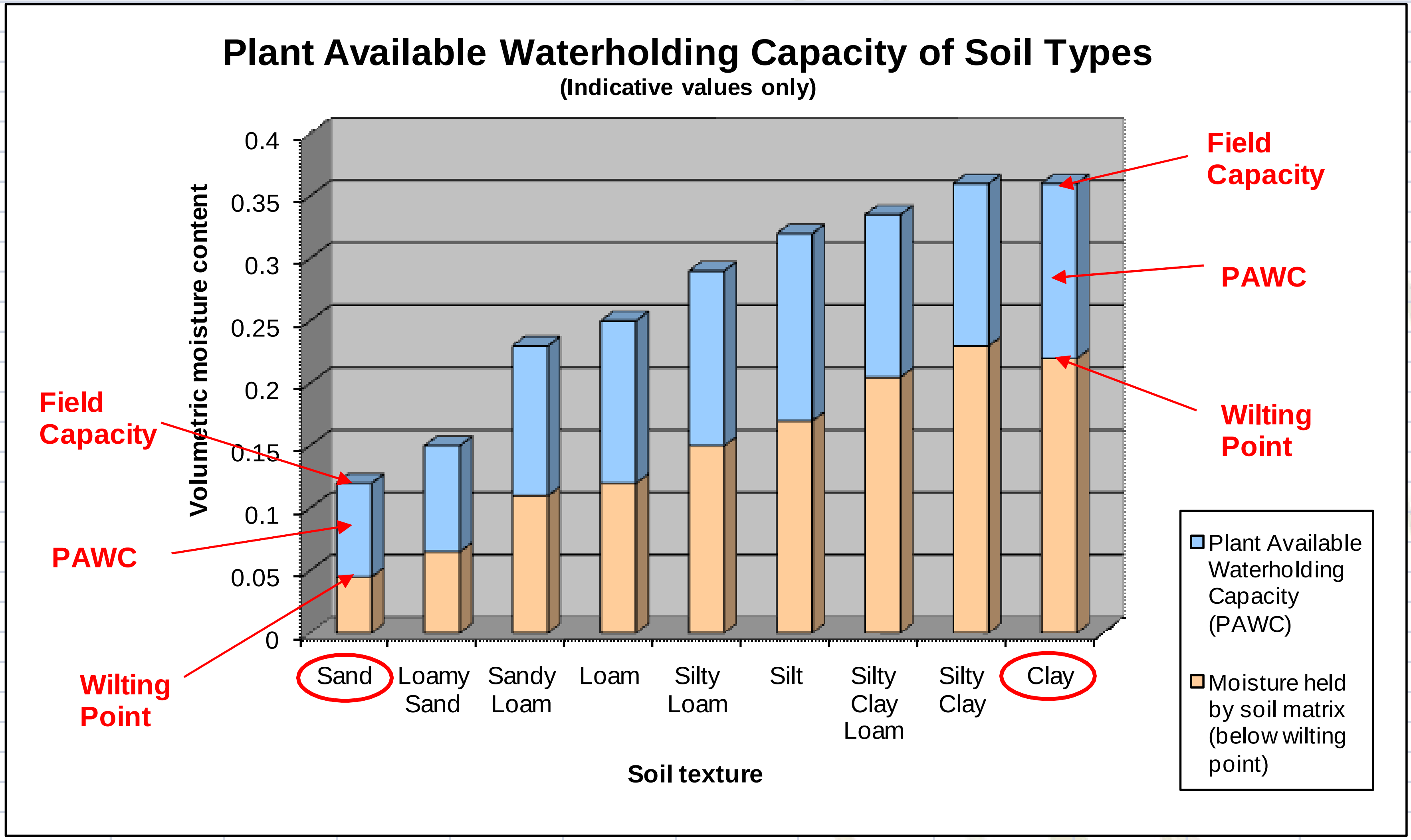


Soils data ? (for APSIM)

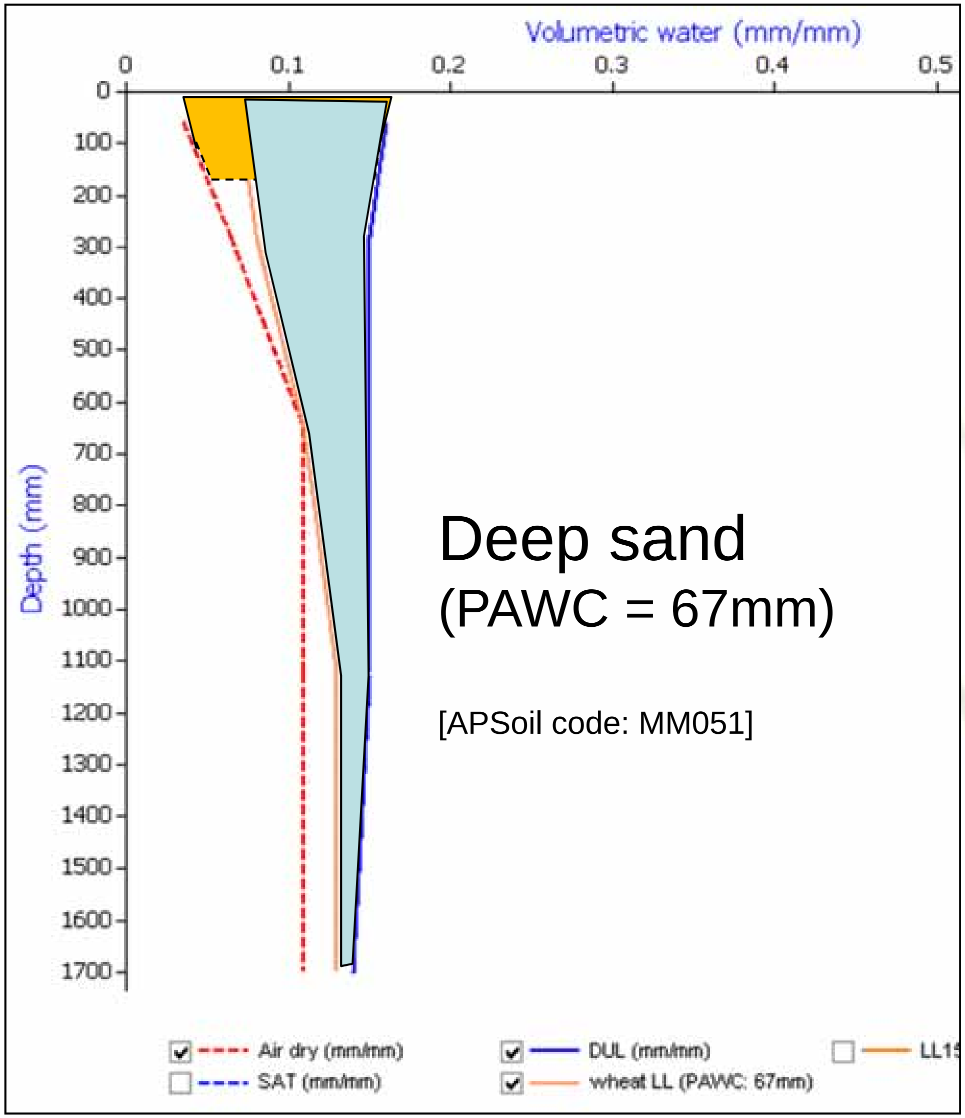
- **"APSoil"** detailed field characterisations
- **http://www.apsim.info/wiki/APSoil.ashx**
- Accessible & growing database
- **<u>BUT</u>** insufficient coverage of the State
- Soil characterisations focus on water holding properties

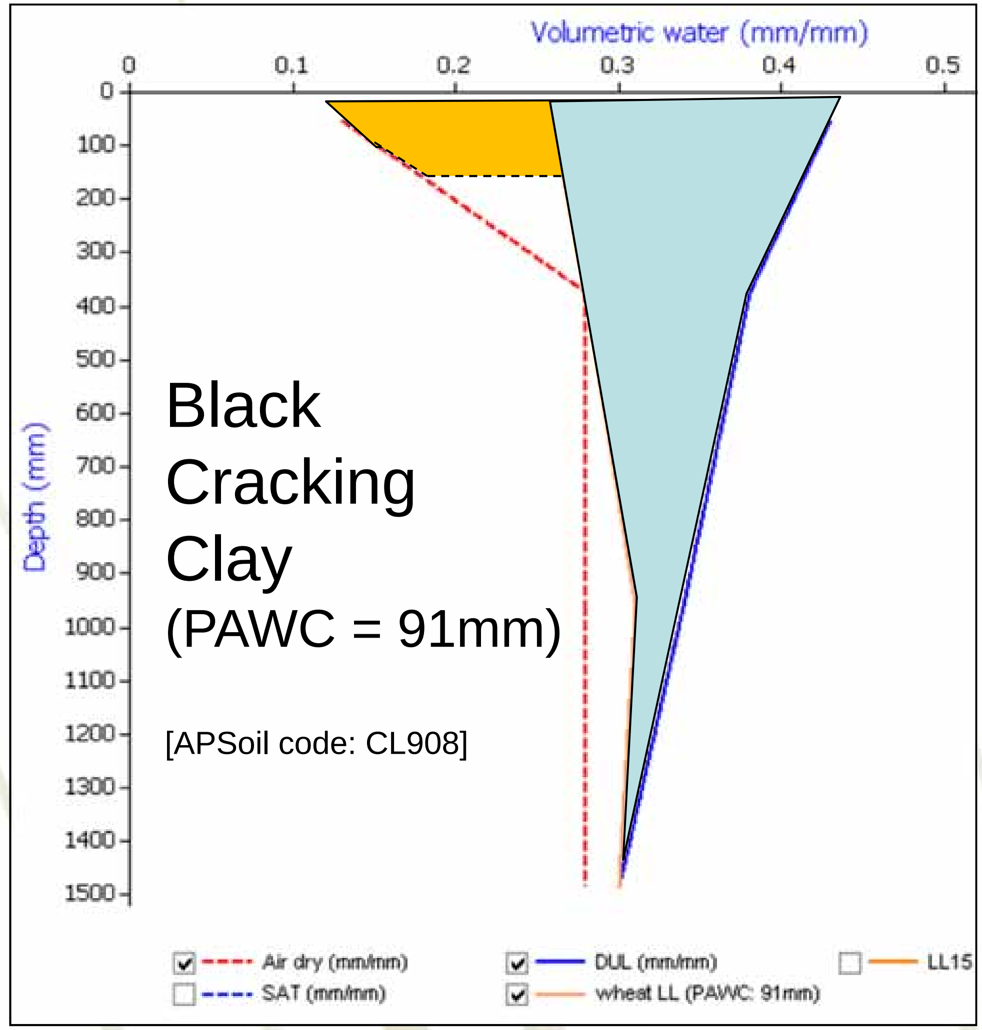


Soils – water holding properties



Soils – water holding properties

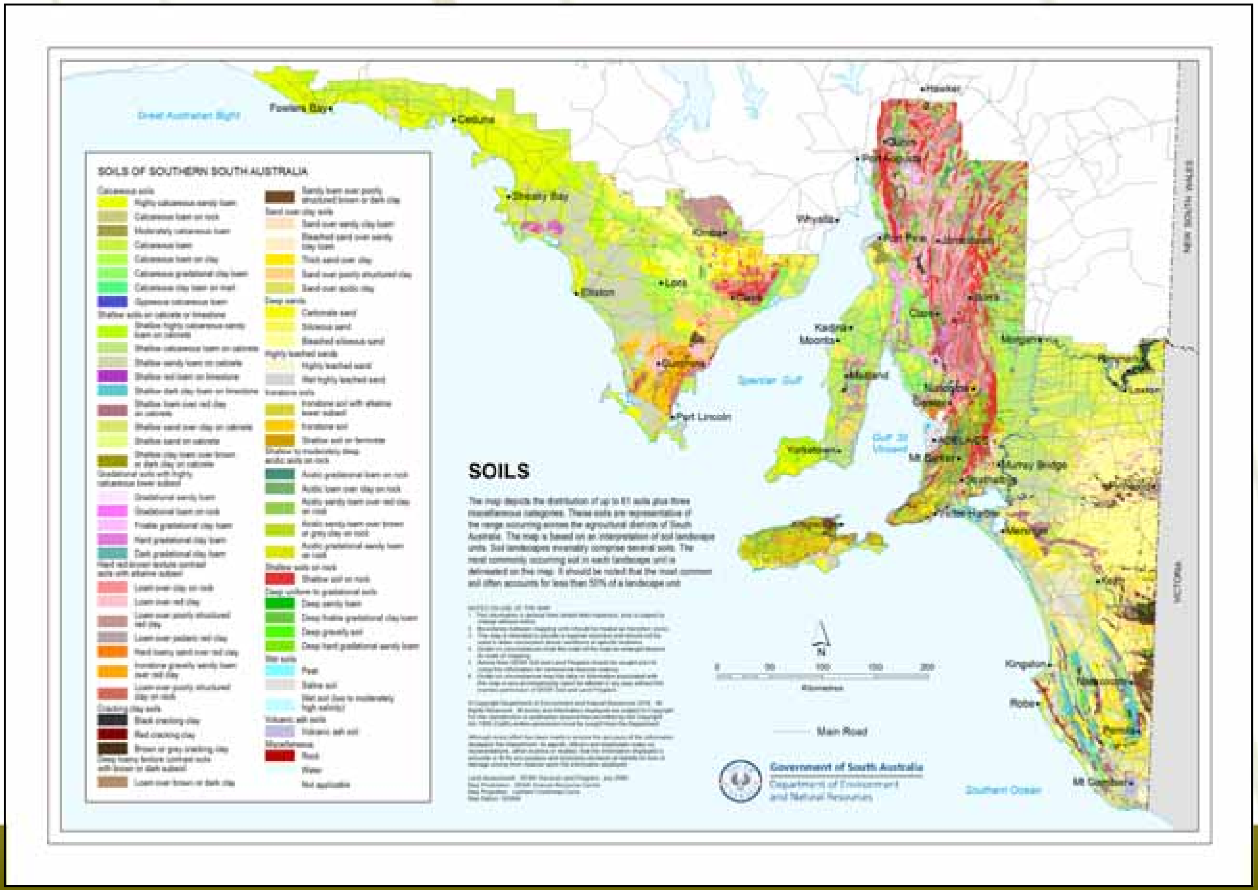




Source: APSoil database v6.30

Soils data ? (for APSIM)

- Conventional approach for broadscale spatial modelling of soils with APSIM – is to choose **dominant soil types** from the *State Land and Soil Information Framework*
- Then assign APSoil/ APSIM style characterisations
- **BUT** – what are we missing out on?

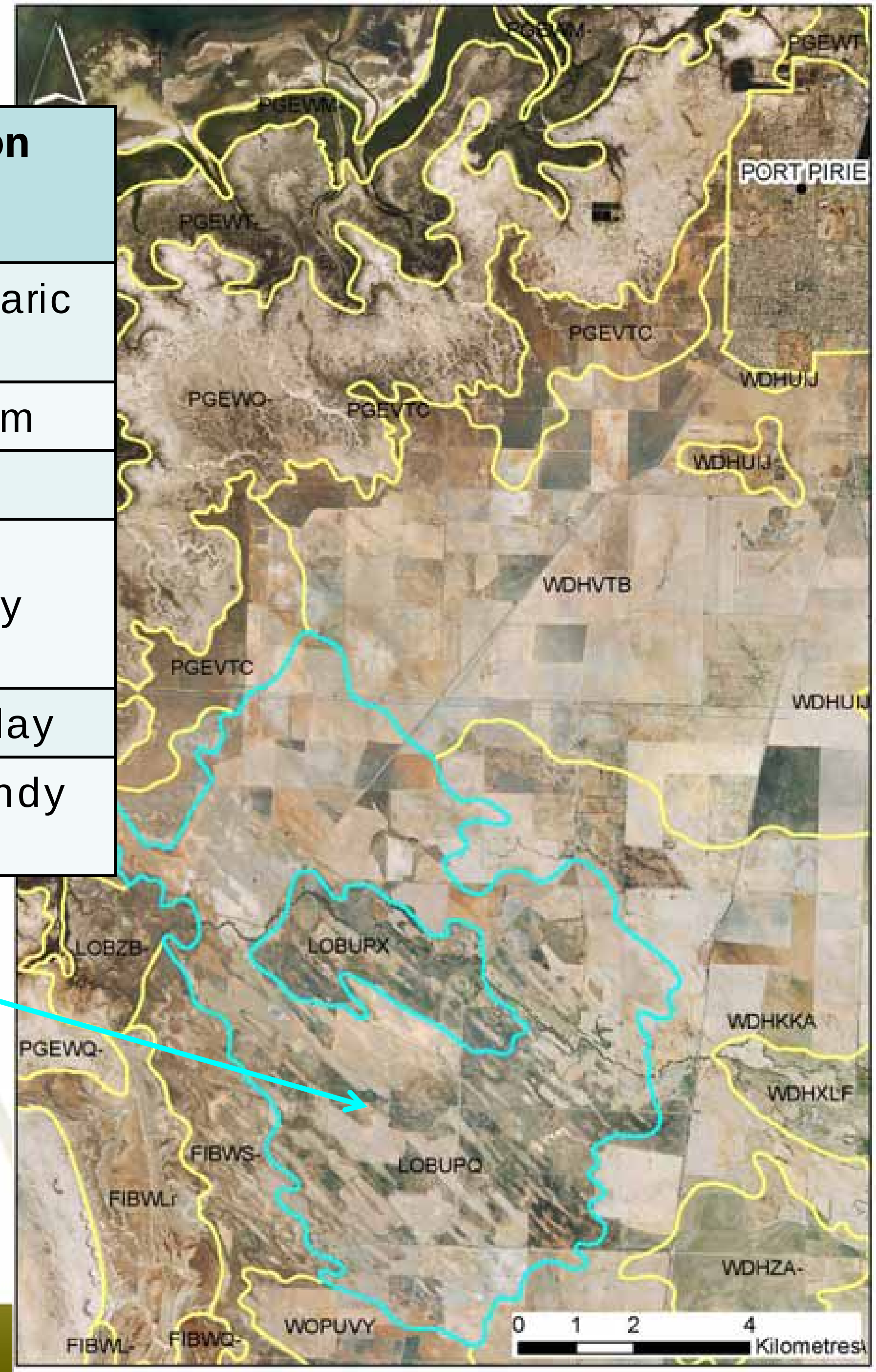


State Land & Soil Information Framework

- 1986-2001 'State Land and Soil Mapping Program'
- Seamless, consistent coverage across agricultural zone
- Mapping at 1:100,000 scale …except 1:50,000 scale in higher rainfall and intensive use areas (MLR, Lower SE, KI & lower YP)
- Two-tiered hierarchy: (i) Land Systems, (ii) Soil-Landscape map units
- 61 Soil Types recognised – as % area components within map units (multiple soil types occur in each map unit due to scale of mapping)
- Across SA - 60,000 soil landscape map units, with 15,000 distinct map unit or 'LANSLU' labels
- 'LANSLU' labels are coded to reflect hierarchy of LS and SLU

Reference: Hall et al 2009

LANSLU	ASRIS Soil type (components)	Soil % Area [5651 ha]	Basic description
LOBUPQ	D4BS	5	Loam over pedaric red clay
	A4PS	25	Calcareous loam
	H2C	45	Siliceous sand
	A6SS	5	Calcareous gradational clay loam
	E2BS	5	Red cracking clay
	C1BS	15	Gradational sandy loam



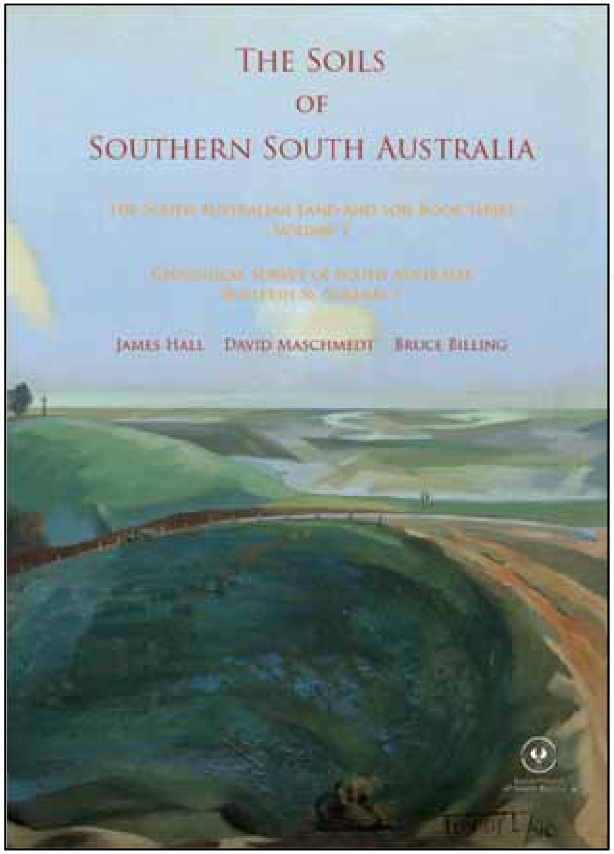
Dominant soils may only occupy 30 - 40% of a map unit

Sub-dominant soils often occupy large areas of the landscape

State Land & Soil Information Framework

- Over 40 land and soil attributes, of importance for land use and management, have been assessed - for all soil components across the agricultural lands of the State.
- Recently, an additional set of nationally consistent soil & land attributes have been derived for the Australian Soil Resource Information System (**ASRIS**, www.asris.csiro.au)
- This ASRIS data format provides the basis for estimating PAWC, % surface clay, and a link into the Statewide crop simulation modelling.
- ASRIS dataset recognises around 1500 soil type variants, from the original 61 Soil Types.
- For more information …

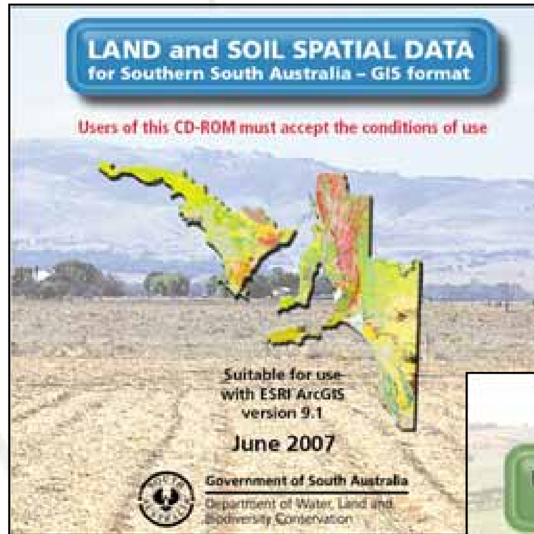
State Land & Soil Information Framework

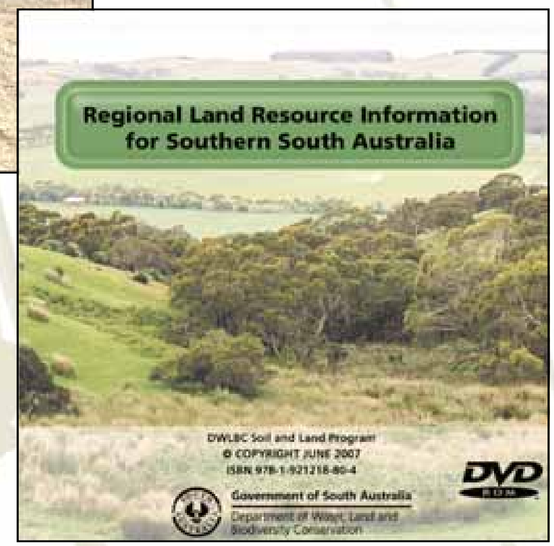


"The Soils of Southern SA"

Available from: PIRSA Customer Service

Or contact : James.Hall@sa.gov.au





PDF & GIS data CD/ DVDs

Contact : Jan.Rowland@sa.gov.au

Soils data (for APSIM)

- This project has dropped the convention for spatial crop simulation modelling which overlooks large areas of sub-dominant soils
- Key challenges were to:
  i. Make better use of the State's detailed soil and land information
  ii. Overcome the lack of "APSoil" field characterisation data (particularly water holding properties)

“Modelling Soil Types”

Surface % Clay Content

PAWC or “bucket size” (mm)

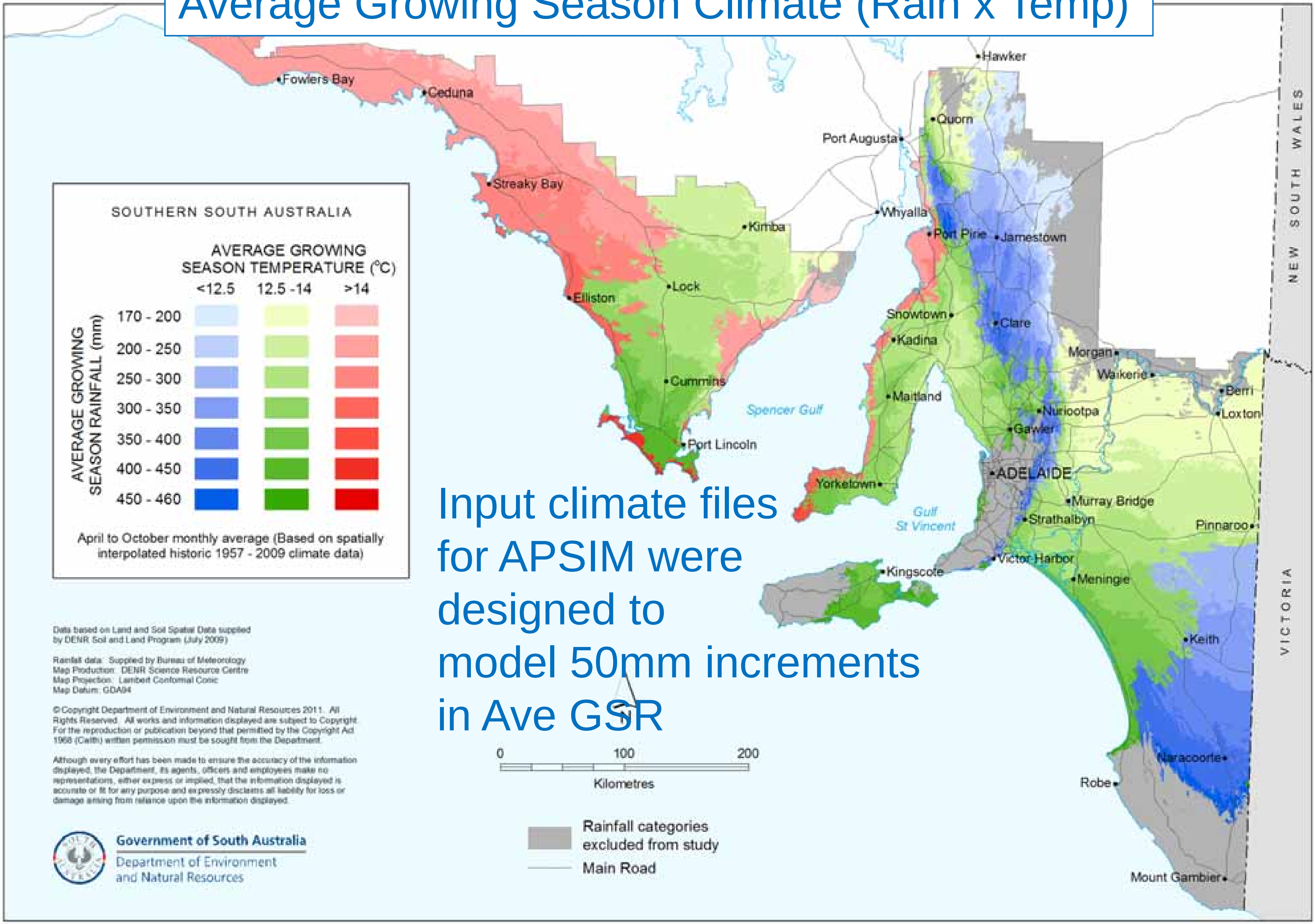
	0 – 5 % *(3.75%)*	**5 – 10 %** *(7.5%)*	**10 – 20 %** *(15%)*	**> 20 %** *(30%)*
30 – 50 mm *(40 mm)*	Shallow sand	✓	✓	Shallow clay
50 – 70 mm *(60 mm)*	✓	✓	✓	✓
70 – 90 mm *(80 mm)*	Deep sand or Sand over clay	✓	✓	✓
> 90 mm *(120 mm)*	Deep sand or Sand over clay	✓	✓	Deep clay

APSIM characterisations were developed for these 16 model soils

Climate data ?

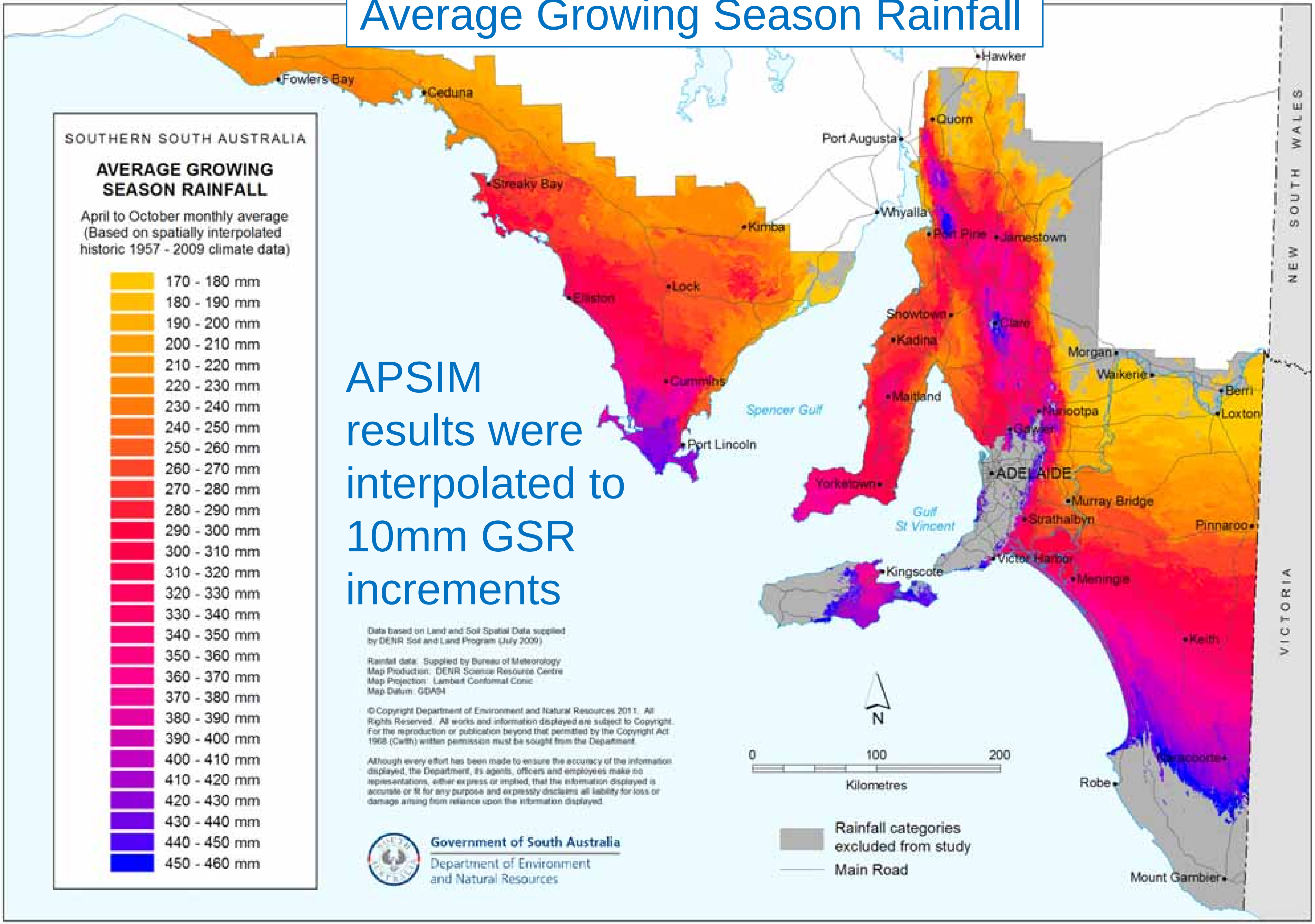
- Requirements for APSIM climate files:
  - Daily rainfall & min/max temperature
  - Long-term
  - Quality
  - Representative of regional variation across State (multiple sites)
  - (Ideally) consistent format for data handling
- **<u>BUT</u>** in reality – insufficient coverage of quality climate station data across the State
- Key challenges were to:
  i. Define appropriate climate zone classes to model in APSIM
  ii. Decide how to distribute APSIM results spatially
  iii. Identify representative daily climate files

Average Growing Season Climate (Rain x Temp)



Input climate files for APSIM were designed to model 50mm increments in Ave GSR

Average Growing Season Rainfall



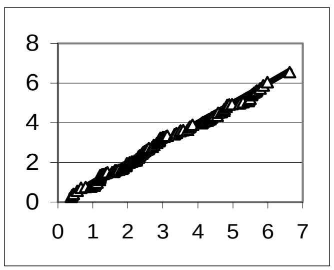
APSIM results were interpolated to 10mm GSR increments

Climate data

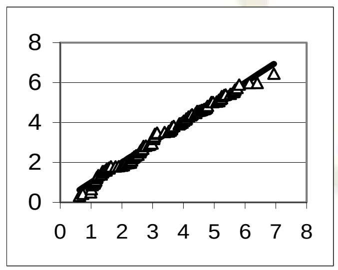
- How did we obtain representative daily climate files?
- SARDI tested a theory ....

Can we adjust daily rainfall and temp from a good quality climate file, to a different mean growing season climate – to model other locations ?

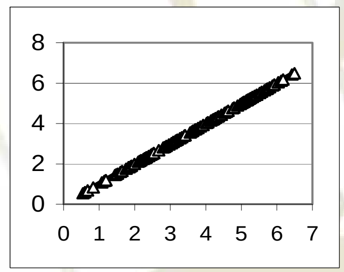
Snw VarS



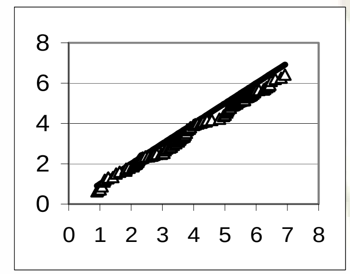
Balaklava	-11	
Correl	0.997	
RMSE	0.14	
	Site	Adj
Mean	3.0	2.9
St Dev	1.6	1.6
CV	56%	55%
Skew	0.29	0.2
Kurt	-1.0	-1.0



Kadina	-6	
Correl	0.995	
RMSE	0.16	
Site	Adj	
	3.2	3.2
	1.6	1.6
	50%	51%
	0.2	0.1
	-1.0	-1.1



Snowtown	0	
Correl	1.000	
RMSE	0.00	
Site	Adj	
	3.5	3.5
	1.6	1.6
	47%	47%
	0.0	0.0
	-1.1	-1.1



Roseworthy	4	
Correl	0.997	
RMSE	0.34	
Site	Adj	
	3.9	3.6
	1.7	1.6
	44%	45%
	-0.2	-0.2
	-1.1	-1.1

Tested percentile-percentile plots for adjusted Snowtown against available site data.
(i) Snowtown (Ave GSR 307mm) worked well. (ii) Maitland used for YP.

Climate scenarios

i. **No climate change**
Based on historic data, atmospheric CO_2 concentration 390ppm

ii. **–5% Relative rainfall change**,
temperature change (max & min) +1.5° C, atmospheric CO_2 concentration 480ppm

iii. **–10% Relative rainfall change**,
temperature change (max & min) +1.5° C, atmospheric CO_2 concentration 480ppm

iv. **–20% Relative rainfall change**,
temperature change (max & min) +1.5° C, atmospheric CO_2 concentration 480ppm

Consistent with the projected envelope of likely change by 2030 (CSIRO & BoM 2007)

Key variable **Rainfall** – due to uncertainty, and rainfall is key limitation to production

60% surface cover, 2 t/ha wheat stubble

75% surface cover, 3 t/ha wheat stubble

DWLBC 2009

Erosion risk assessment

Actual on-ground assessments are based on:

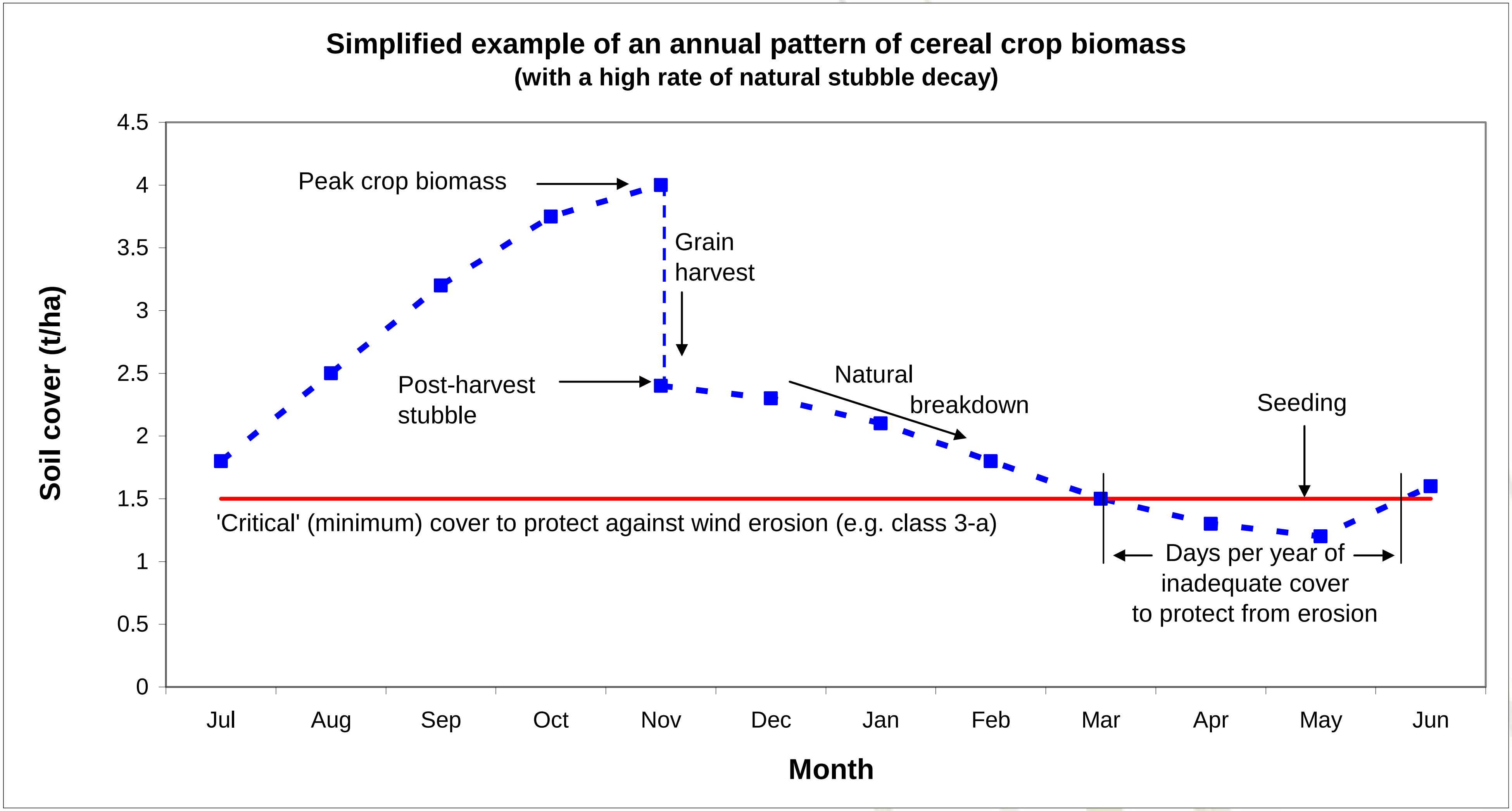
- Inherent site susceptibility (soil & land type, slope, annual rainfall zone)
- Management (soil disturbance / looseness)
- Cover (height, % surface cover, bulk, anchorage)
- Exposure (days/year in bare or loose condition)

Source: DENR

This modelling uses a simplified indicator:

- Post-harvest stubble cover (t/ha) – as determined by APSIM & compared to critical cover requirements estimated for different land classes.

Erosion risk assessment



2.6 t/ha stubble biomass

4.4 t/ha stubble biomass

Erosion risk assessment

Critical cover to protect land from erosion:

- Estimates were derived from expert opinion
- Based on **wind** and **water erosion land classes**

"Erosion risk" occurrence defined when:

- **Post-harvest biomass < Critical cover (at harvest)**

Assumptions:

- No disturbance / grazing of biomass
- Critical cover (at harvest) allows for 30% natural decay factor, to provide adequate protection during the following seeding period

Photos: Mary-Anne Young (Rural Solutions SA)

Erosion risk assessment

Critical cover requirements

Wind erosion prone land			**Water erosion prone land**		
Land class:	***At harvest (t/ha)***	*At seeding (t/ha)*	*Land class:*	***At harvest (t/ha)***	*At seeding (t/ha)*
1-a	**0**	0	1-e	**0**	0
2-a	**0.9**	0.6	2-e	**1.4**	1
3-a	**2.1**	1.5	3-e	**2.9**	2
4-a	**3.6**	2.5	4-e	**4.3**	3
5-a, 7-a	N/A	N/A	5-e, 6-e, 7-e	N/A	N/A

Other mapping procedures

- Land included / excluded:
  - Only land use from a rotational cropping/ grazing system
  - Non-arable land identified and excluded
  - Growing season rainfall within range thought suitable for cropping (170-460mm)
- Erosion risk analysis (post-harvest biomass compared to critical cover at harvest) – performed at the soil component level
- Map unit values are an area weighted average of soil components

For enquiries about draft Statewide maps for predicted:

- Average grain yields
- Ave post-harvest biomass
- Frequency & severity of erosion risk

Please contact:

Susan.Sweeney@sa.gov.au
or
Craig.Liddicoat@sa.gov.au

Implications for land managers

- For low rainfall cropping areas, results reinforce field observations:
  - Clayey surface soils have highest evaporative water loss & can be more 'risky'
  - Sandy surface soils with high PAWC ('bucket size') are more reliable (/ less prone to failure), and can offer better returns in poor seasons
- 5% rainfall decline tends to counteract potential CO_2 benefits
- Erosion risk shows gradational impacts – frequency & extent of potential risk areas increases with a drying climate.
- Further analysis is required for Statewide climate change scenarios
- Potential to highlight areas to watch; and target programs exploring alternative sustainable land management options

In Summary

- This project has applied innovative techniques to:
  - make the best use of available data
  - overcome data shortfalls
  - increase cost-effectiveness of modelling efforts
- Largely achieved through the use of:
  - "Modelling soil types"
  - Adjusted daily climate files (using quality datasets to model other sites)
- Modelling limitations & assumptions need to be recognised by stakeholders and other end users
- Further verification, review and discussion of implications from this work will need to occur in consultation with regional stakeholders

Thank you

Any questions ?