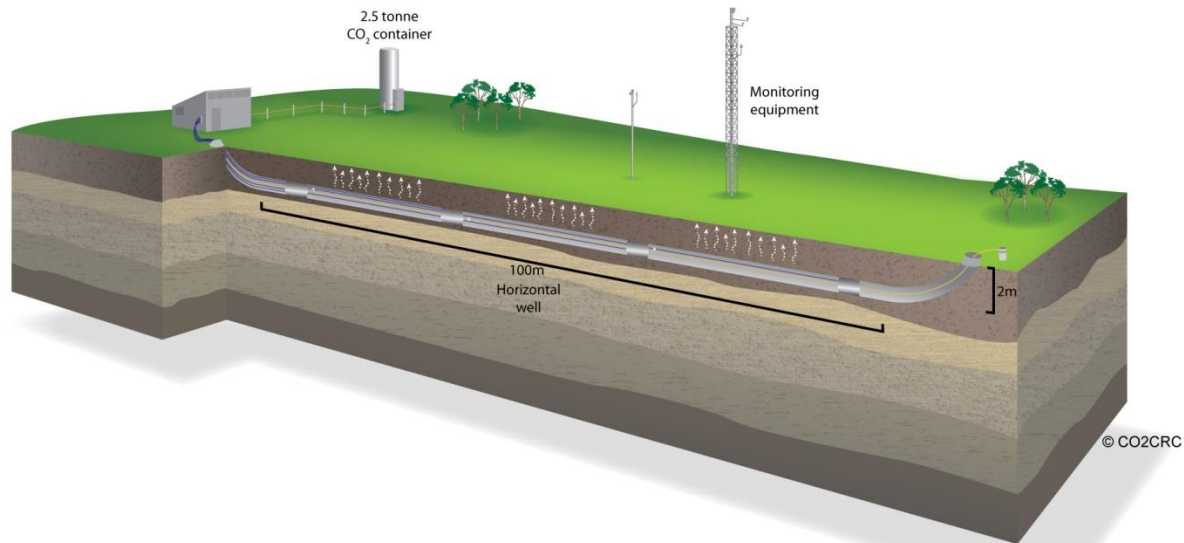




ARB CCS technical discussion: soils and atmosphere

Dr Andrew Feitz

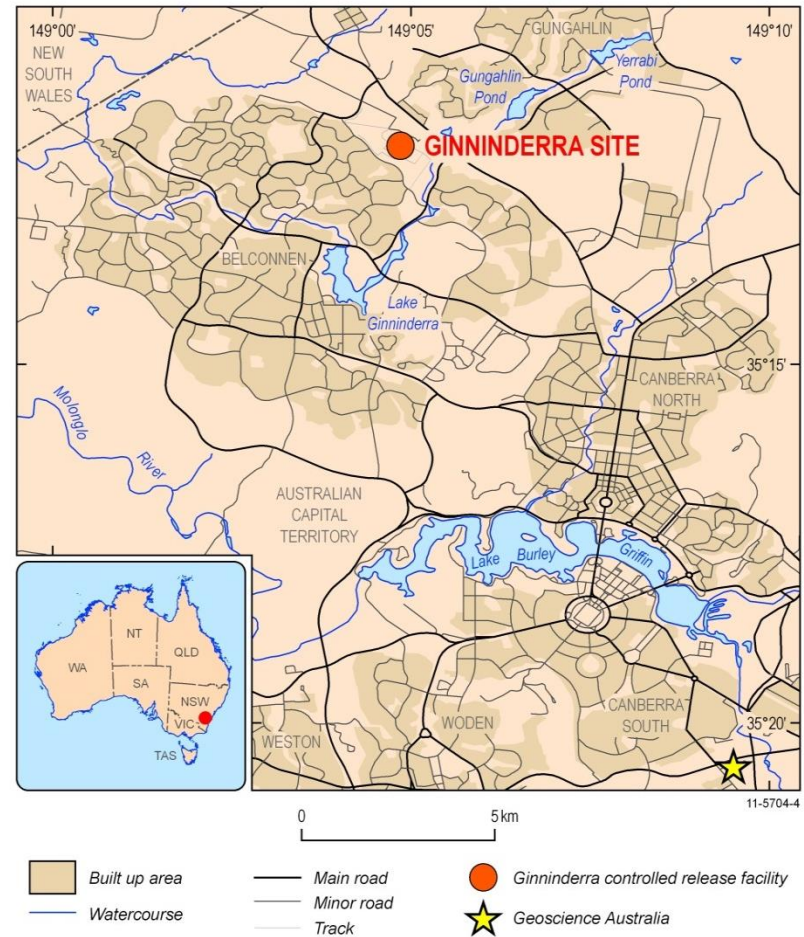


Questions

1. What risk does a CO₂ leak pose to biological life in the soil? For example, how might CCS negatively impact microbes and/or plant root systems?
2. Given some CO₂ gas is naturally present in most soils, how much CO₂ can be present in the soil before negative impacts are observed? Please be specific on the scale and intensity of impacts.
3. Once a leak is stopped, is soil recovery from the negative impacts possible, and if so, how long would it take? What conditions might affect this recovery rate? What methods are available to speed soil recovery? How much do such methods cost?
4. What risk does a CO₂ leak pose to biological life if released into the atmosphere? What impact would it have on plants, animals, and humans?
5. Given that CO₂ gas is naturally present in the atmosphere, how much CO₂ can be present in the air at ground level before negative impacts are observed? Please be specific on the scale and intensity of impacts. Does the space that the leak enters affect these concentrations (e.g., open area, topographical depression, basement/building)?
6. Should health risks due to leaks of CO₂ to the soil or atmosphere be addressed by the CCS QM or are those risks better addressed by the local permitting and CEQA and NEPA2 determinations?

Ginninderra controlled release facility

- Collaboration between Geoscience Australia and the CO2CRC
- Hosted at CSIRO Ginninderra Experiment Station
- 800 hectares of cropping/grazing land
- Fluvial soils
- **Aim: Evaluate the effectiveness of different monitoring techniques**



Three sub-surface release experiments

- 2 x 144 kg CO₂/d
- 288 kg CO₂/d
- 7-9 weeks continuous injection
- 2012 - 2013



Ginninderra - techniques trialled to date

- Soil gas
- Soil flux
- Soil analysis
- Atmospheric tomography
- Scanning laser
- Eddy covariance
- Tracer studies (soil gas and atmospheric analysis)
- Ground penetrating radar
- Airborne CO₂ detection using a rotorcraft UAV
- Electromagnetic surveys
- Airborne hyperspectral and thermal imaging
- In-field phenotyping (hyperspectral, thermal, 3D imaging)
- Microbial soil genomics
- Plant biochemistry and physiology

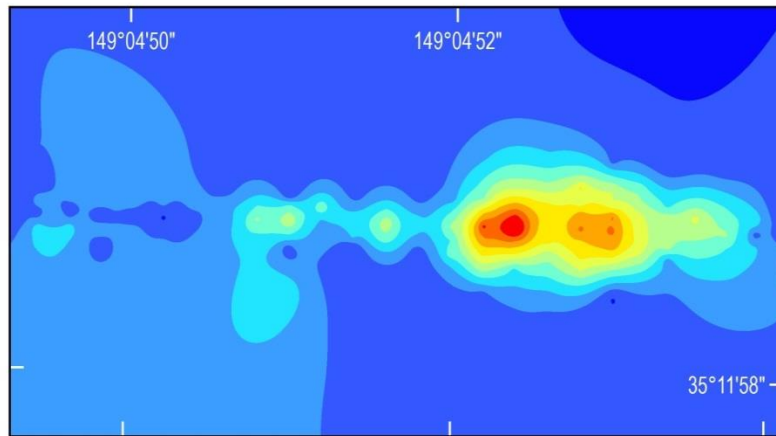


Leak is “patchy” and moved depending on climatic conditions

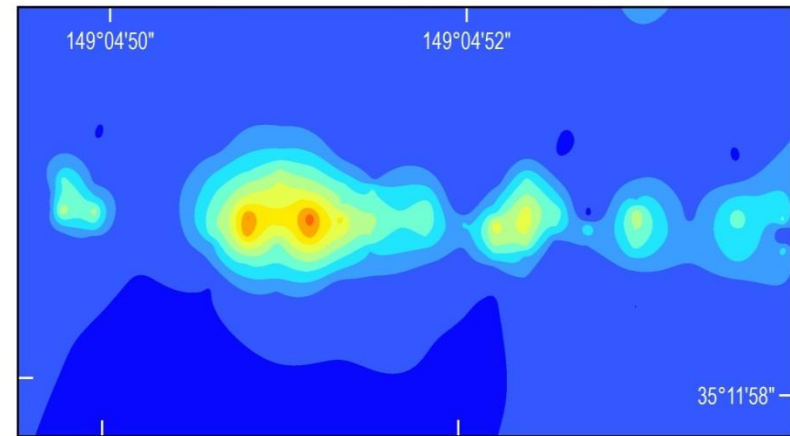
(Wet season)

(Dry season)

a. 2012



b. 2013



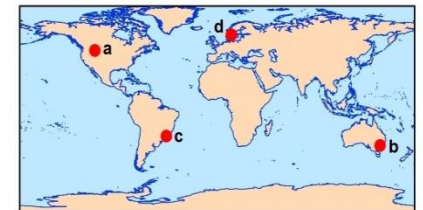
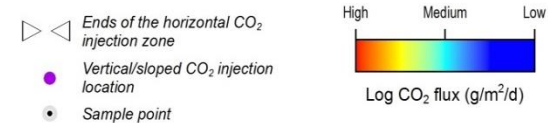
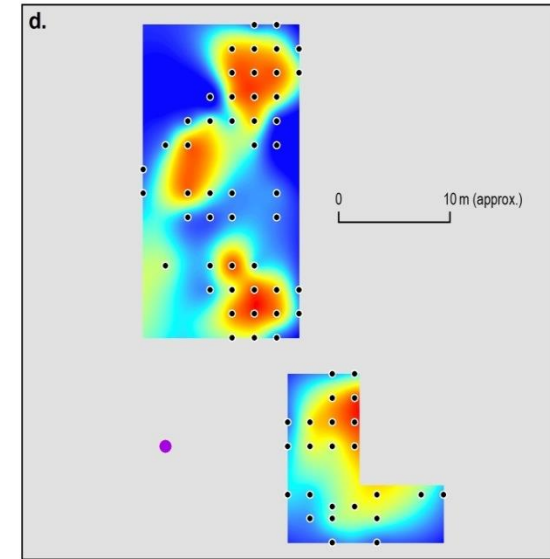
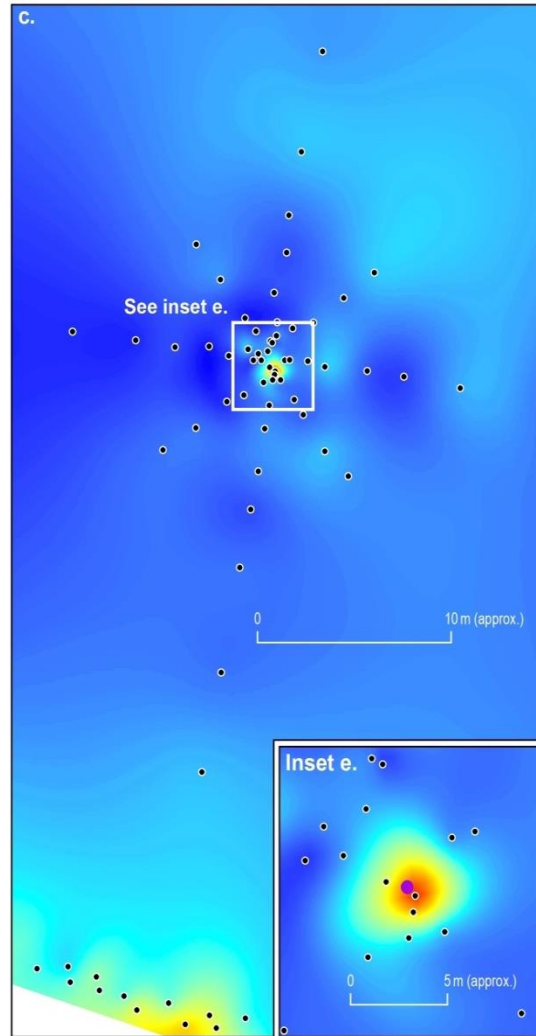
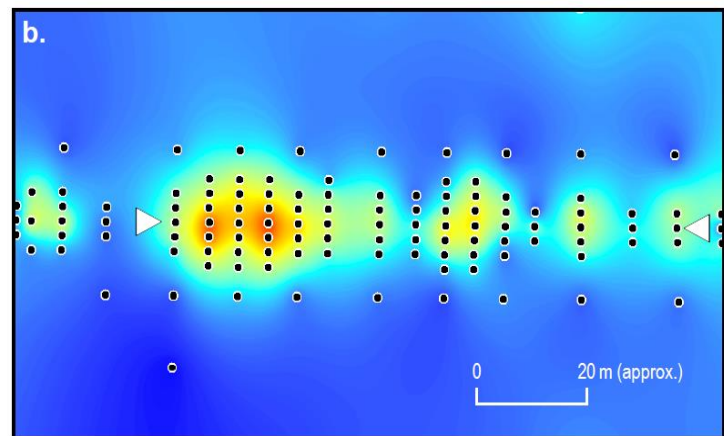
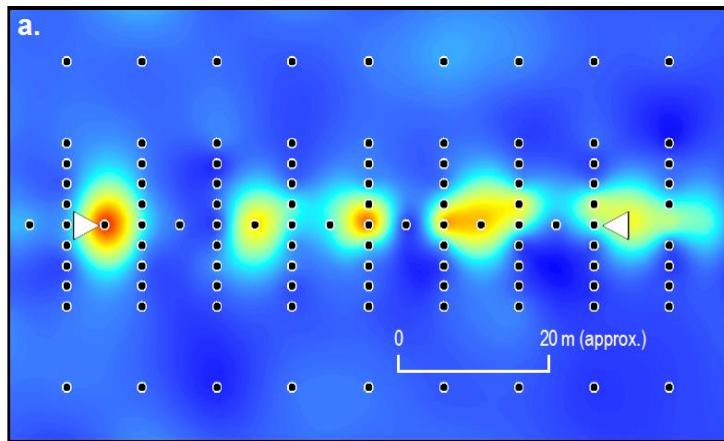
0 30 m

14-8438-3

Log CO₂ flux(g/m²/d)



Similar leakage features observed worldwide



a. ZERT, USA c. RESSACADA, BRAZIL
b. Ginninderra, AUSTRALIA d. CO₂ Field lab, NORWAY

14-8490-1

Question 1?

What risk does a CO₂ leak pose to biological life in the soil? For example, how might CCS negatively impact microbes and/or plant root systems?

Can kill plants and change microbial populations, but area of impact localised

CO₂ impact on plants clearly visible, but small in area

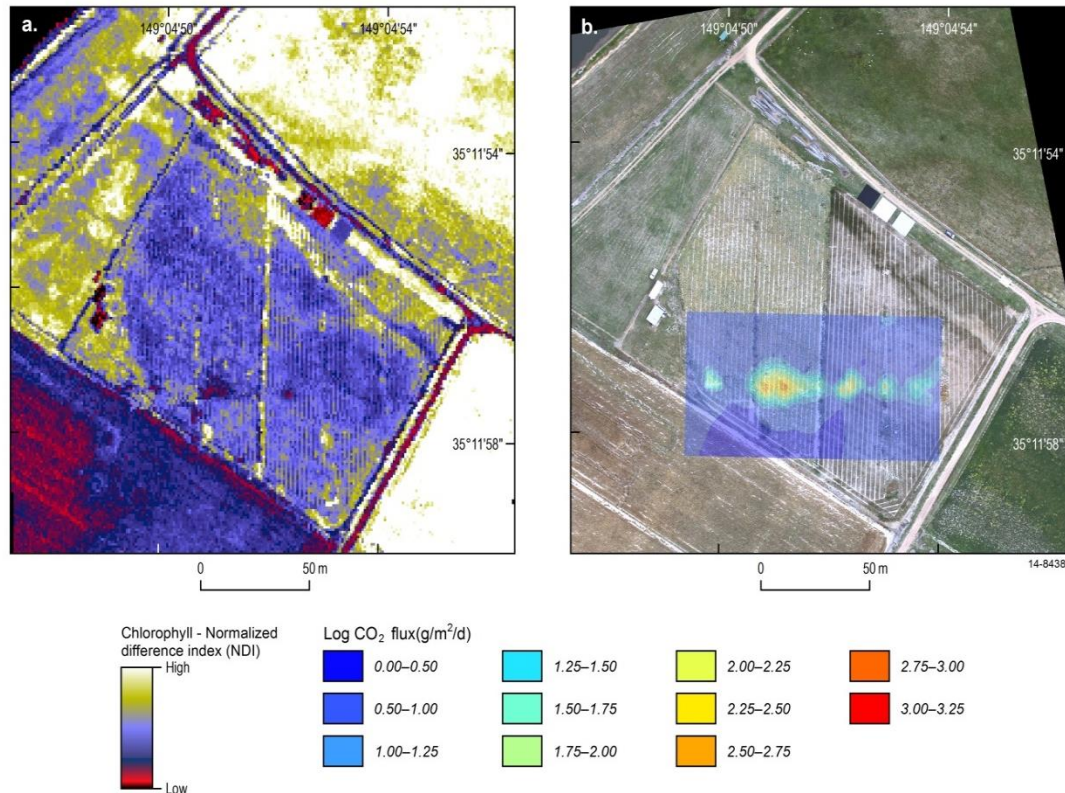
Background

2 weeks exposure to CO₂



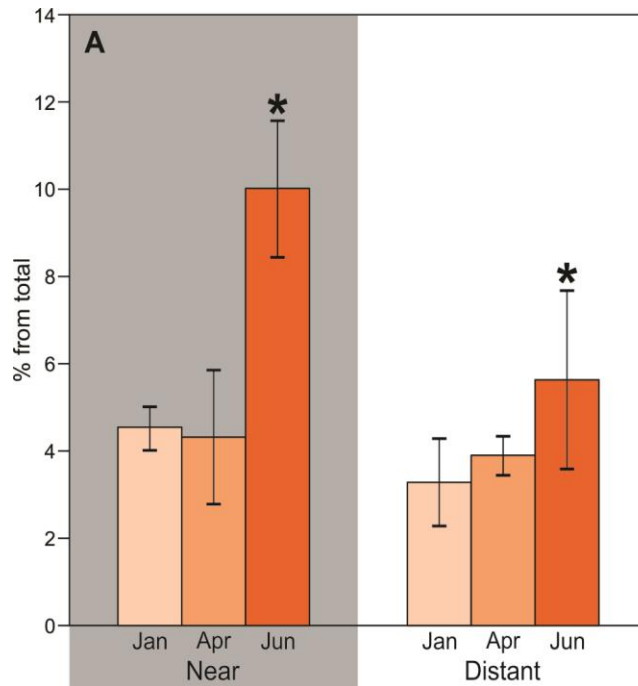
... but not using airborne techniques

- CO₂ impacts on vegetation clearly visible at ground level, but current airborne technique suffer from many false positives
- **Plant affected area smaller than that detected elevated soil flux/gas levels**

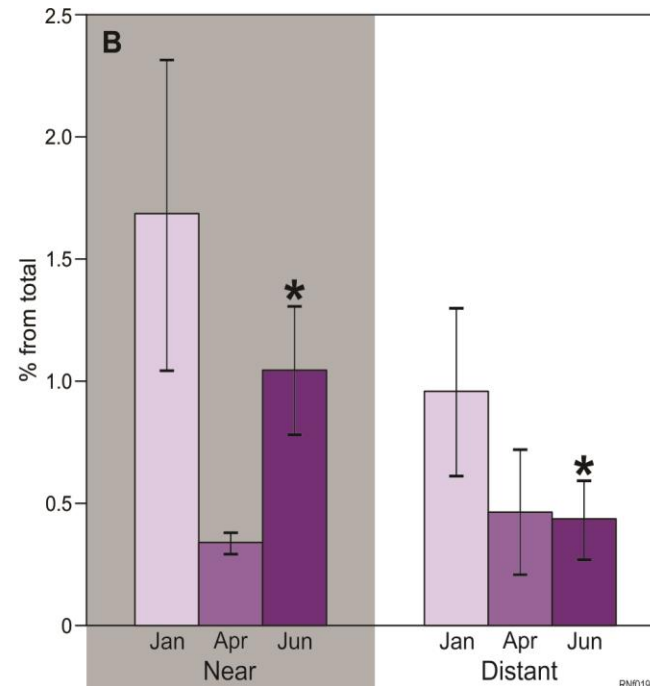


Observed shift in microbial populations towards more anaerobic, acid/metal tolerant species

Firmicutes



Nitrospira



Natural CO₂ leaks at Latera Caldera, Italy

~20 t/d natural CO₂ leak, but localised

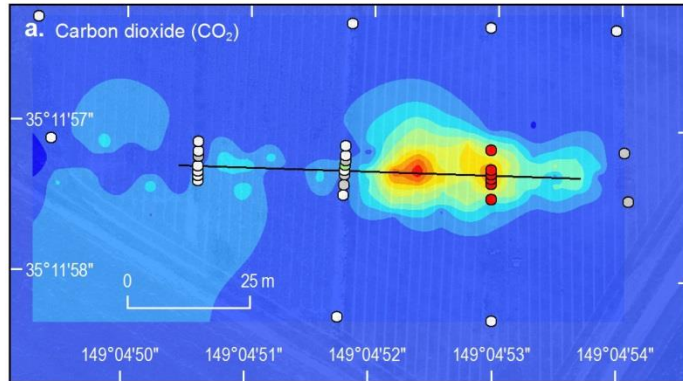


Question 2?

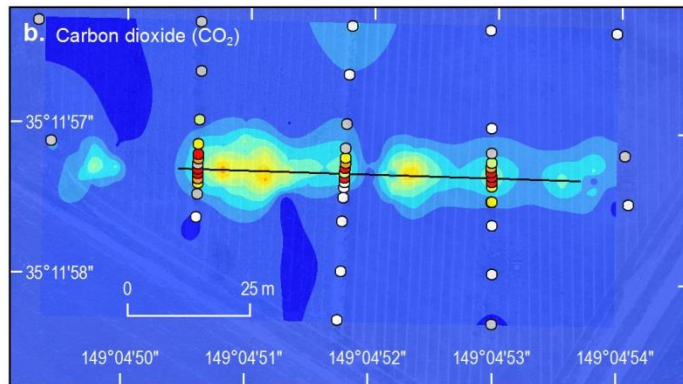
Given some CO₂ gas is naturally present in most soils, how much CO₂ can be present in the soil before negative impacts are observed? Please be specific on the scale and intensity of impacts.

Observed detrimental plants impacts at CO₂ >40%, limited between 5 - 40% depending on plant type

Relationship between surface and soil gas (1m)



CO₂ surface flux expression
 < CO₂ soil gas footprint (1m depth)

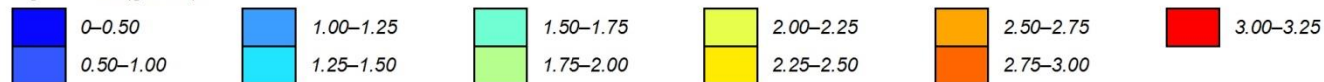


Depends on groundwater levels and
 extent of vadose zone ++

Carbon dioxide (CO₂) soil gas concentration (%)

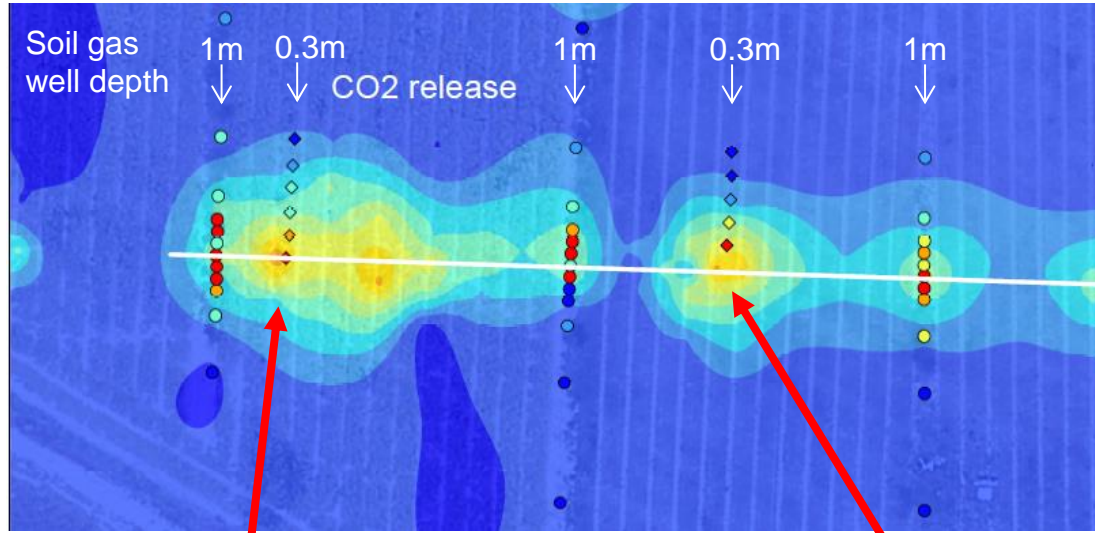
- <1.5 ● 5.0–10.0 ● 25.0–40.0
- 1.5–5.0 ● 10.0–25.0 ● >40.0

log CO₂ flux(g/m²/d)

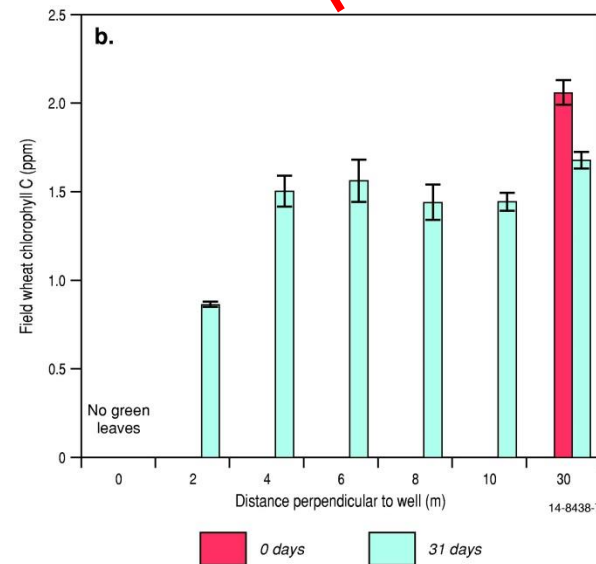
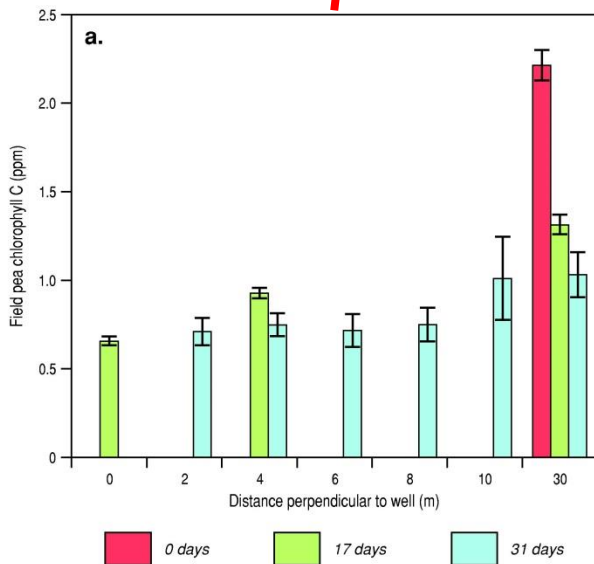


Plant impacted area small, but different plants have different sensitivities to CO₂ in soil gas

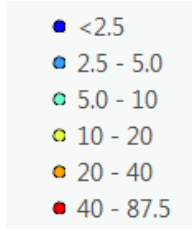
Field peas



Wheat



% CO₂ in soil gas



Question 3?

Once a leak is stopped, is soil recovery from the negative impacts possible, and if so, how long would it take? What conditions might affect this recovery rate? What methods are available to speed soil recovery? How much do such methods cost?

- Yes, ~ months at Ginninderra. No adverse impact observed in tillering plants (~2 weeks old) <5 months after closure of last experiment.
- CO₂ soil gas back to background < 12 weeks after stopping CO₂
- Size of leak/ volume of CO₂ in vadose zone/ still buoyancy-pressure drive to CO₂ plume?
- Natural atmospheric pumping probably sufficient

Question 4?

What risk does a CO₂ leak pose to biological life if released into the atmosphere? What impact would it have on plants, animals, and humans?

- Since CO₂ heavier than air, only a problem if atmosphere is still, there is a lot of CO₂, and it accumulates in hollows, basements, burrows
- Slightest breeze, and CO₂ quickly disperses to atmospheric concentrations marginally above background within meters of release point
- May have a crop fertilization effect on adjacent plants (enhance growth)



Question 5?

Given that CO₂ gas is naturally present in the atmosphere, how much CO₂ can be present in the air at ground level before negative impacts are observed? Please be specific on the scale and intensity of impacts. Does the space that the leak enters affect these concentrations (e.g., open area, topographical depression, basement/building)?

- Depends on atmospheric stability and size of leak.
- Accumulations in depressions, basements a key risk factor (equip at risk facilities with gas detectors, similar to Radon?)
- TWA exposure standard 5,000 ppm
- Studies show crop fertilization effect at ~500+ppm

Question 6?

Should health risks due to leaks of CO₂ to the soil or atmosphere be addressed by the CCS QM or are those risks better addressed by the local permitting and CEQA and NEPA2 determinations?

- Recommend that each project assesses risk of CO₂ accumulations in basements etc via a risk management process, i.e. project specific.
- Risk needs to consider location of potential leakage pathways, e.g. wells and faults.
- Each site will be unique in terms of risks and possible leakage pathways.



Australian Government
Geoscience Australia



Any further questions?

ARB CCS 27 September 2016