Carbon Sequestration in Plantstones

The next generation of carbon sequestration solutions

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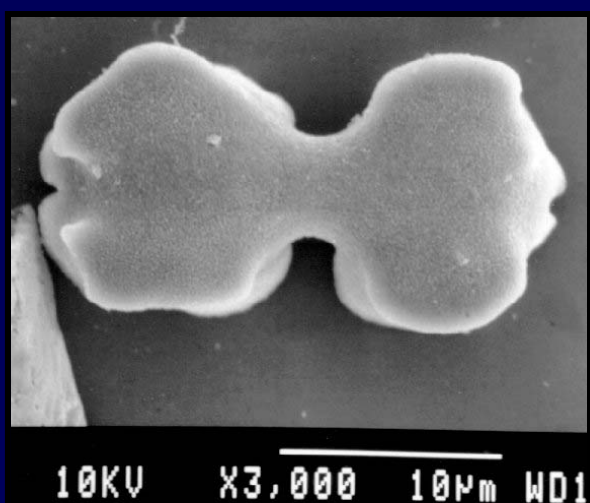
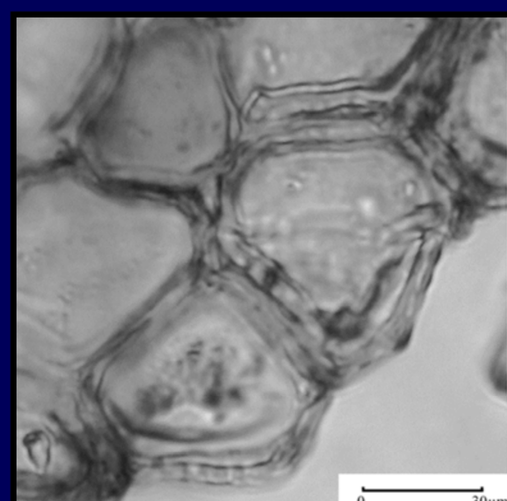
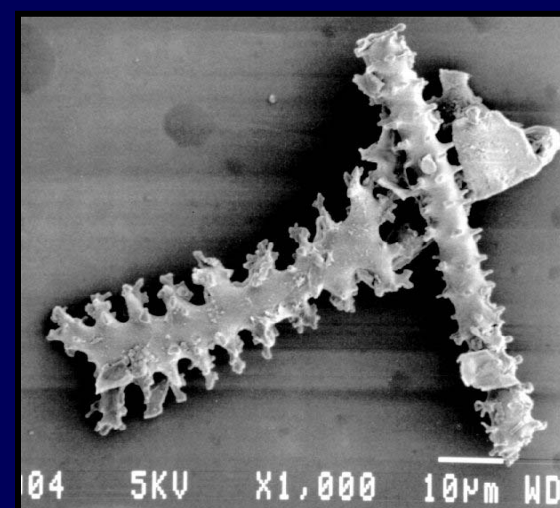






Tradable carbon sequestered in Australia is currently restricted to the carbon that is accumulated in woody plants.

Eucalypt Plantations

Pine Plantations

Mallee tree strips between grain crops

CO2 Australia

A slight problem …

•*Forests are very important carbon sinks, however, the land area covered by old growth forest and available for farm-forestry, plantation timber and strip plots is limited due to our needs for land to produce food.*

Forests cover 7% of world land mass	**People use 25% of world land mass**

•*The introduction of new methods of emission free energy production is also going to play a major role in CO_2 reduction but, this will be a slow and long-term process to implement.*

•*CO_2 needs to be reduced ASAP by a range of processes.*

•*All deserving equal attention.*

Agricultural Approach …

- *One solution to the shortage of landscape for sequestering carbon is to increase this process in agricultural soils.*

- *Agricultural grain crops cover an area of 20 million hectares annually in Australia alone. We cannot afford to aside this land for woody plant production because we need to eat as well as sequester more carbon.*

- *We can introduce no-till direct drill agriculture to lock up carbon.*

The Plantstone Approach …

- *Our contribution/solution to the shortage of landscape for sequestering carbon is to increase this process in:*

- *Agricultural soils*

- *Degraded lands (acid sulfate or salinity affected) and,*

- *Wetland areas (natural or constructed).*

Agricultural soils,

Acid sulfate soils,

Saline soils and,

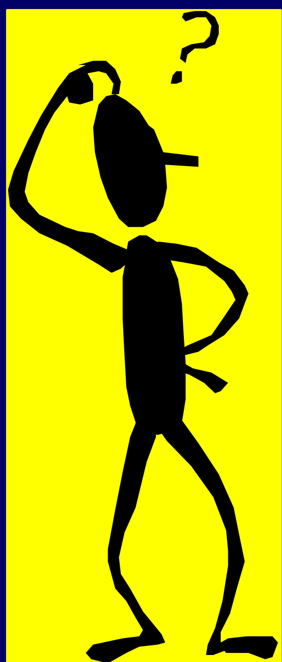
Wetland areas

(1)
Can be important areas of herbaceous plant production.

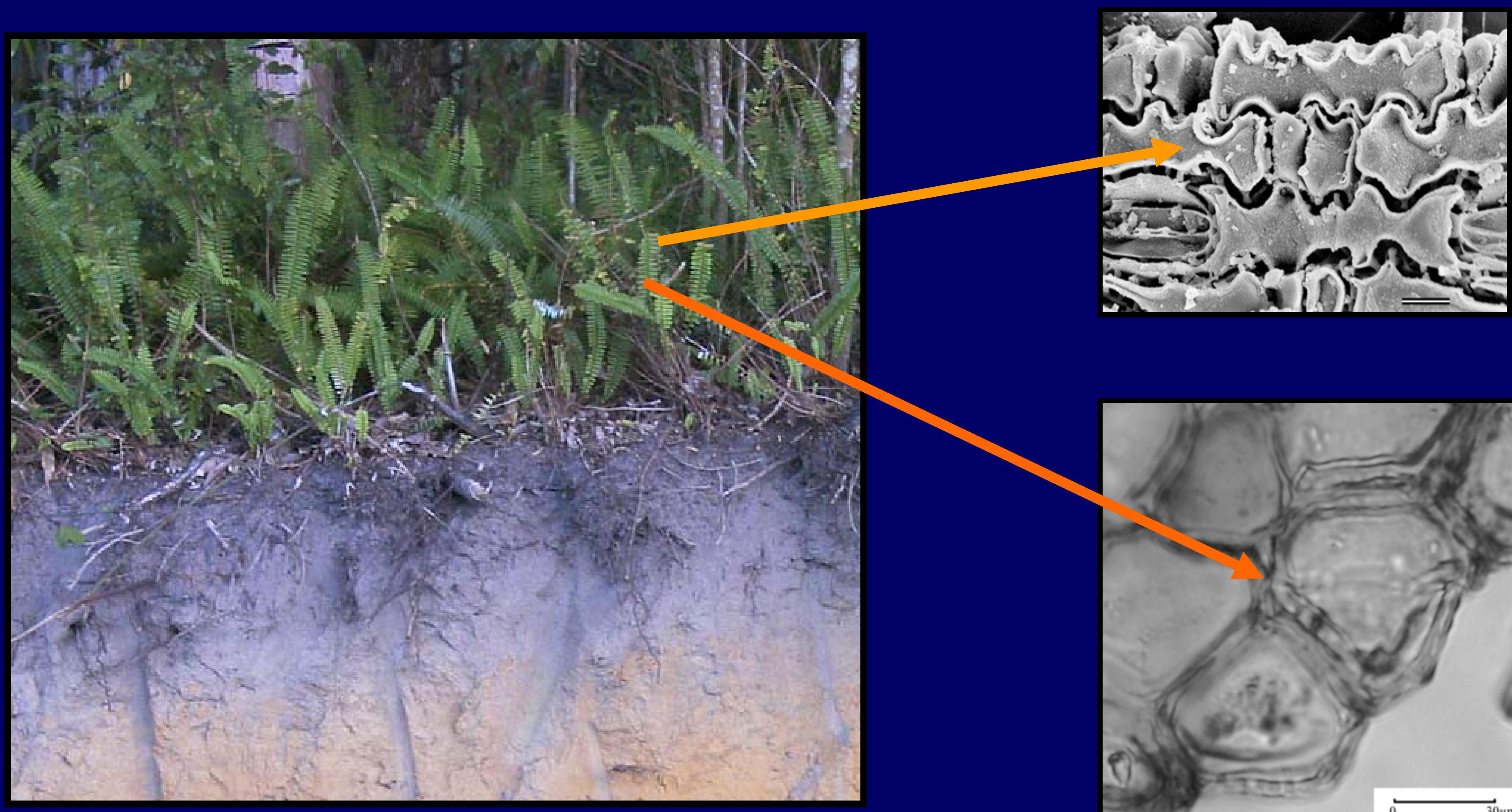
(2)
All herbaceous plants particularly grasses produce Plantstones.

(3)
Plantstones of many grasses and other herbaceous plants efficiently sequester carbon.

So what are Plantstones?
Plantstones are also referred to as phytoliths or plant opal. They are silicified cell structures formed within many plants as a result of silicic acid $Si(OH_4)$ uptake from soil.



This hydrated silica moves throughout the plant impregnating cell walls forming thick coatings of silica opal that encapsulates the organic carbon content.



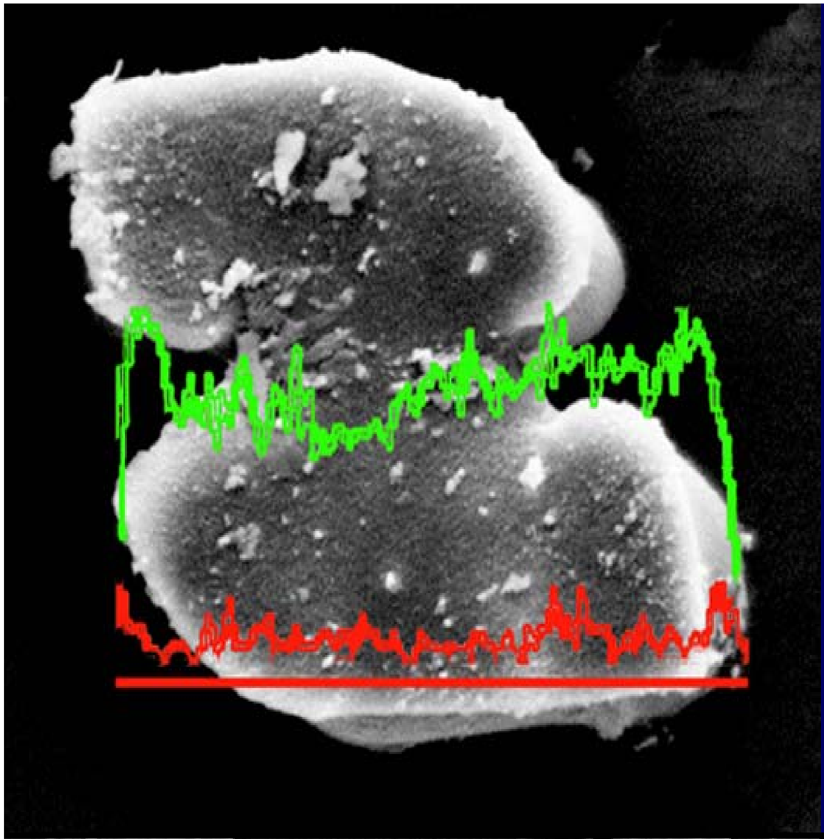
The organelles of a plant cell are composed of organic material - carbon.

This organic carbon is encased within the plant cell by silica forming a plantstone.

This organic carbon occluded in plantstones we call PhytOC

Phyto = plant

OC = organic carbon

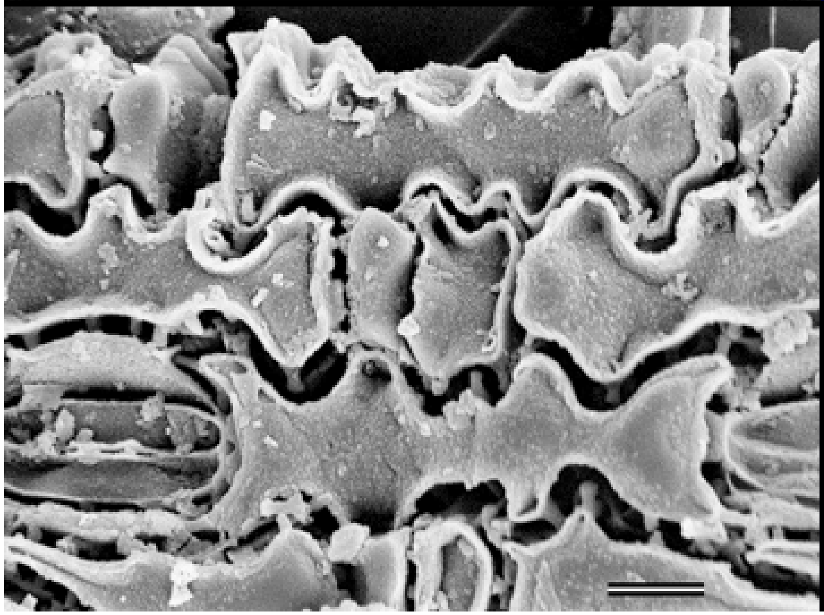


Scanning electron micrograph of a solid bilobate type plantstone.

The microprobe analysis for Carbon and Silica.

The green line represents the silica content.

The red line represents the carbon content.



Scanning electron micrograph of epidermal long cell plantstones.

Proof of concept ?

Done

Proven in the natural laboratory

Proven in Field trials

Proven by extensive laboratory analysis

Our research to date

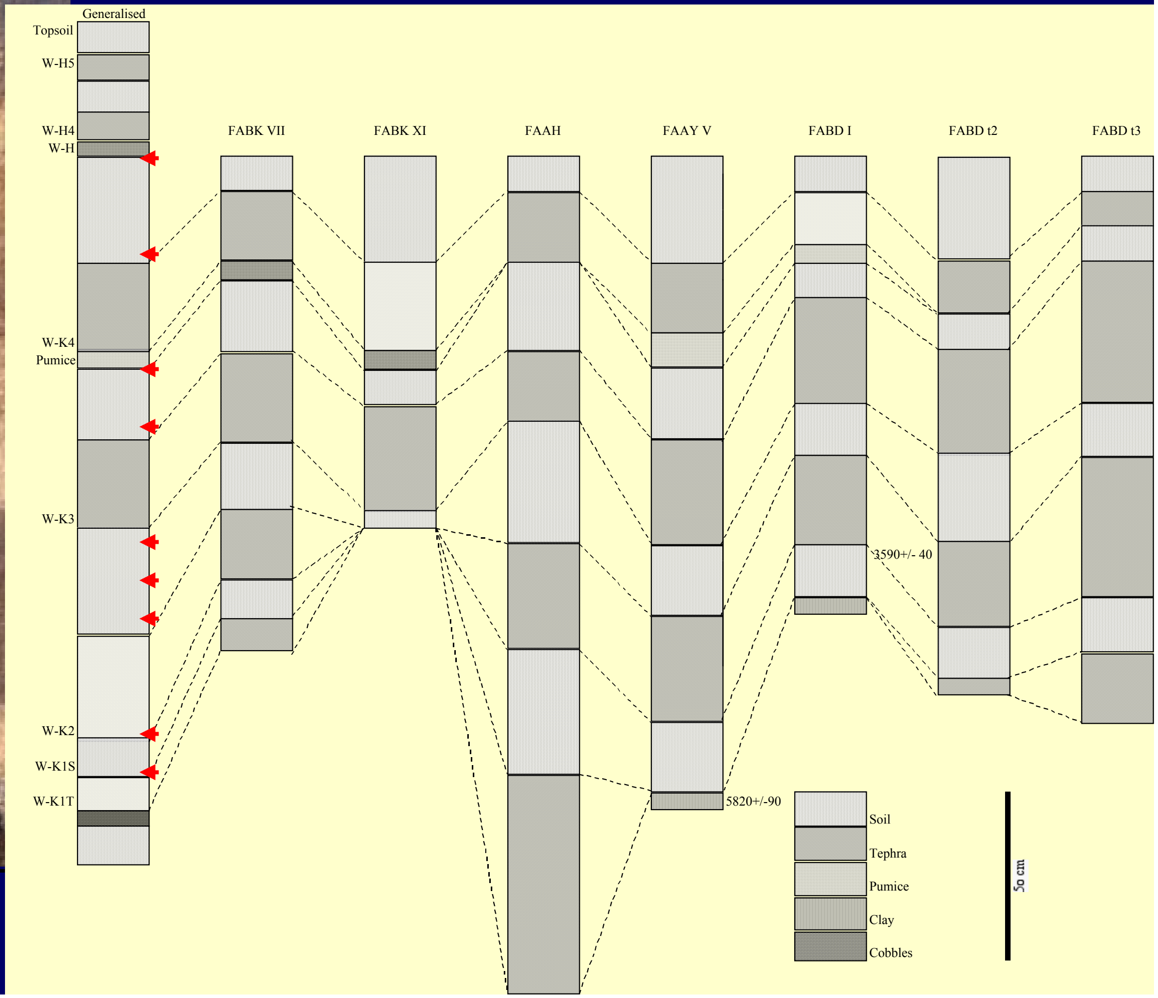
Radiocarbon dated the carbon in the Plantstones themselves.

Plantstones - resistant to decomposition in a range of soils to at least 35,000 yrs.

We have examined over 500 samples to date from modern soils and paleosols.

West New Britain PNG

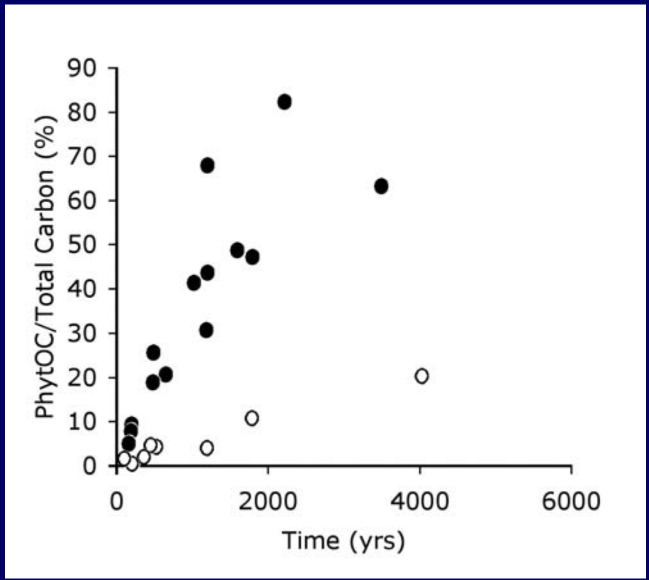
Volcanic sediments

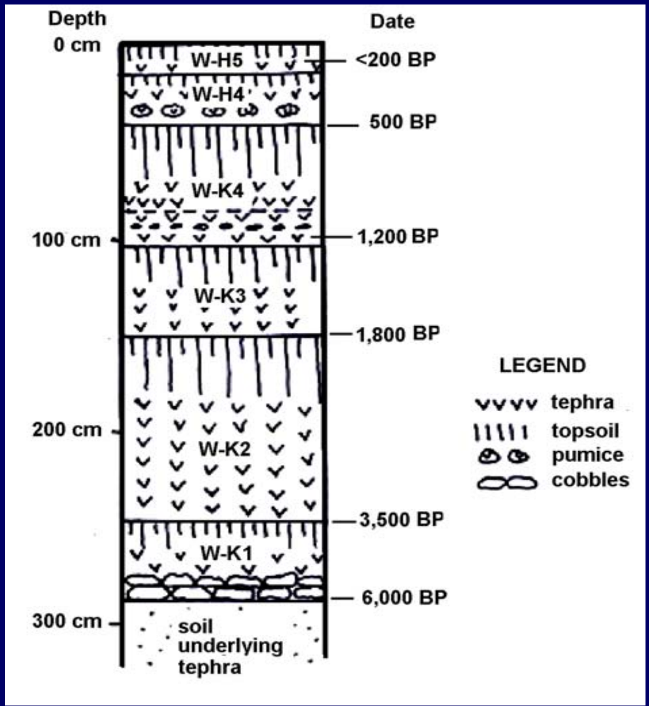


Byron Bay NSW

Acid sulphate soils

Samples
PNG and
Byron Bay
5cm intervals





Data for these modern soils and paleosols revealed that up to 82% of total carbon occurring after 2000 years is PhytOC.

'Plantstone organic carbon'

Plantstone concentrations ranged from 15% to 44.88% of soil weight under a range of vegetative conditions.

We have screened the abundance of Plantstones in over 230 plant species native to PNG and eastern Australia

Abundance of Plantstones in over 230 plant species native to PNG and eastern Australia. *e.g.(Parr and Sullivan 2005)*

Abundance of extracted phytoliths from herbarium specimens assessed visually on glass slides at 400× magnification from plant species occurring at both the Numundo and Byron Bay sites

High

Asteraceae: *Vernonia cinerea* (L.) Less., Blechcaceae: *Blechrum indicucm* Burm. F., Cyperaceae: *Gahnia sieberana* Kunth., Moraceae: *Artocarpus cumingiana* Trec., *Ficus coronata* Spin., Myrtaceae: *Eucalyptus robusta* Smith, Pandanaceae: *Pandanus tectorious* Solms., Poaceae: *Bambusa forbesii* (Ridl.) Holttum, *Brachiaria brizantha* (Hoscht. Ex A. Rich) Stap *f.*, *Buergersiochloa macrophylla* S.T. Blake, *Blumea Supp.*, *Coix lachryma-jobi* L., *Hetaropogon triticus* (R.Br) Stapf. Ex Cralb, *Imperata cylindrica* P.Beauv., *Imperata exaltata* (Roxb.) Brogn., *Ischaemum polystachyum* (L.), *Polytoca macrophylla* Benth., *Saccharum officinarum* (L.), *Saccharum robustum* (L.), *Seteria sphacelata* (K. Schum.) Stapf. & C.E. Hubb, *Schizostachym brachycladum* (Blanco) Mer., *Themeda arguens* (L.) Hack, *Thysanolsara maxima* (Roxb.) O.K., Pteridophyta: *Diplazium esculentum* (Retz.) Sw., Rubiaceae: *Massaenda ferruginea* K. Sch. Var. *scandens* Val., *Timonius sp.*, Scrophulariaceae: *Buchnera tumentosa* Bl., Simaroubaceae: *Ailanthus integrifolia* Lamk.

Medium

Annonaceae: *Annona muricata* L., Arecaceae: *Areca catachu* L., *Caryota rumphiana* Mart., *Cocas nucifera* L. Burseraceae: *Canarium indicum* L., Combretaceae: *Terminalia catappa* L., Cucurbitaceae: *Bryophyllum pinnatum* (Lamk) Kurz., *Luffa cylindrica* (L.) Roem., Cyperaceae: *Cyperus kyllingia* Endl., Moraceae: *Ficus nodosa* Teysm. & Binn, *Ficus papus* Peekel, *Ficus pungens* Reinw. ex Bl., Myrtaceae: *Eucalyptus maculata* Hook., *Leptospermum sp.*, Piperaceae: *Piper betal* L., Pteridophyta: *Nephrolepis hirstulata* (Forst.) Presl, Rubiaceae: *Massaenda ferruginea* K. Sch. Var. scandens Val., Rutaceae: *Euodia hortensis* J.R.&G. Forst., Sapotaceae: *Burckella obovata* (Forst.) Pierre, Simaroubaceae: *Quassia indica* (Gaertn.) Nooteboom

Low

Acanthaceae: *Hemigraphis reptans* (Forst. F.) And. ex Hemsley, Amaranthaceae: *Cyathula prostrata* Bl., Anarcardiaceae: *Dracontomelon dao* (Blanco) Merr & Rolfe, *Spondias dulcis* Soland. ex Forst., Annonaceae: *Cananga odorata* Hook., Apocynaceae: *Alstonia scholaris* R. Br., *Cerbera manghas* L., *Ichnocarpus frutescens* (L.) R. Br., Araceae: *Colocasia esculenta* (L.) Schott., *Schismatoglottis calyptrata* (Roxb.) Zol & Mor., *Pothos helwigii* Engl., Araliaceae: *Polyscias cummingiana* (Presl.) F.-Vill., Arecaceae: *Licuala peckelii* Laut., *Metroxylon sagu* Rottb., *Nypa fruticans* Wurmb., Aristolochiaceae: *Aristilochia tagala* Cham., Barringtoniaceae: *Barringtonia asiatica* L., *Barringtonia novae-hiberniae* Laut., Boraginaceae: *Cordia subcordia* Lamk., Caryophyllaceae: *Drymaria cordata* (L.) Willd. Ex Roem & Schult., Convolvulaceae: *Ipomea batatus* L., *Ipomea congesta* R. Br., Cycadaceae: *Cycus rumphii* Miq., Cyperaceae: *Mapanea macrocephala* (Gaud.) K. Sch., Dioscoreaceae: *Dioscorea pentaphylla* L., Ebenaceae: *Diospyros peekelii* Laut., Euphorbiaceae: *Macaranga aleuritoides* F. Muell., *Macaranga tararius* (L.) Muell.-Arg., *Macaranga urophylla* Pax & Hoffm., *Manihot esculenta* Crantz., Fabaceae: *Canavalia rosea* (Sw.), *Casia alata* L., Flagallariaceae: *Flagallerea gigantia* Hook. f., *Flagallarea indica* L., Flacourtiaceae: *Homalium foetidum* (Roxb.) Benth., *Pangium edule* Reinw., Gnetaceae: *Gnetum gnemon* L., *Gnetum latifolium* L., Goodeniaceae: *Scaevola taccada* (Gaertn.) Roxb., Hernandiaceae: *Hernandia nymphaefolia* (presl) Kubitski, Lamiaceae: *Ocimum basilicum* L., Lauraceae: *Cassytha filiformis* L., *Litsea grandiflora* Teschn., Liliaceae: *Cordyline fruiticosa* (L.) A. Chev., *Cordyline terminalis* Kunth, Malvaceae: *Hibiscus manihot* L., *Hibiscus tiliaceus* L., *Sida rhombifolia* L., Marantaceae: *Donax canniformis* (Forst.) K. Sch., Melastomataceae: *Osbeckia chinensis* L., Moraceae: *Artocarpus cumingiana* Trec., Musaceae: *Heliconia bihai* L., *Heliconia indica* Lamk., *Musa accuminata* (simons), *Musa becarrii*(simons), *Musa erecta* (simons), *Musa paradisica* L., *Musa peekellii* Laut., *Musa schizocarpa* (simons), *Musa truncata* var.horizontalis Holtlum., *Ensete calosperma* F.U.M., Myrtaceae: *Syzigium bevicymum* (Diels) Merr. & Perry *Syzigium malaccence* (L.) Merr. & Perry, Nyctaginaceae: *Pisonia longirostris* Teys. & Binn., Orchidaceae: *Dendrobium bifalce* Lindl., *Dendrobium peekelii* schltr., Piperaceae: *Piper mestorii* F.M. Bail., *Piper peekelii* C. DC., Pittosporaceae: *Pitosporum ferrugineum* Ait., Podocarpaceae: *Dacrycarpus imbricatus* Bl., Proteaceae: *Banksia sp.*,Pteridophyta: *Bolbitis quogana* (Gaud.) Ching, Rhamnaceae: *Alphitonia macrocarpa* Mansf., *Alphitoria molaccana* Reiss. ex Endl., Rhizophoraceae: *Brugiera gymnorrhiza* (L.) Lamk, *Rhizophora apiculata* Bl., Rosaceae: *Cyolendophora laurina* (A. Gr.) Kosterm., *Rubus rosaefolius* Sm., Rubiaceae: *Uncaria bernaysii* F. Muell., Sapindaceae: *Pometia pinnarta* J.R. & G. Forst., Scrophulariaceae: *Lindernia crustaceae* (L.) F. Muell., Solanaceae: *Datura metal* L., *Solanum erianthum* D. Don., *Solanum torvum* Sw., Sterculiaceae: *Heritiera littoralis* Dryand ex W. Ait., *Kleinhohia hospita* L., *Melochia odorata* L. f., Urticaceae: *Dendrocnide warburgii* (Winkl.) Chew, *Leukosyke capitellata* Poir., *Pipturus argenteus* (Forst.) Wedd., Verbenaceae: *Premna serratifolia* L., Xanthorrhoeaceae: *Xanthorrhoea resinosa* Pers.

High: > 66% cover of slide, Medium: > 33 to < 66% cover, and Low: > 1 to < 33% cover.

Observations on plants……

- *Plantstones occur in many plants particularly grasses.*

- *There is a huge variation in the amount of carbon occluded in the plantstones of different plant species.*

Ongoing research……

- *We are currently screening economic plant species and varieties to establish those that are the most prolific producers of Plantstones and PhytOC.*

"The best at sequestering carbon for the long-term."

Recent plants screened for carbon occluding Plantstones

Grain crops

Barley
Canola
Chickpeas
Mustard
Sorghum
Wheat - bread
Wheat - durum

Other grass crops

Sugarcane

Legumes

Faba beans
Pink serradella FHS 3
Purple clover Pur-A
Rose clover 95GCN
Sulla cross
Zulu arrowleaf clover

Regeneration Plants

Coolatai grass
Kangaroo grass
Saltbush
Tall wheat grass

Tamworth and other plant PhytOC trials

Sorghum

Breadwheat

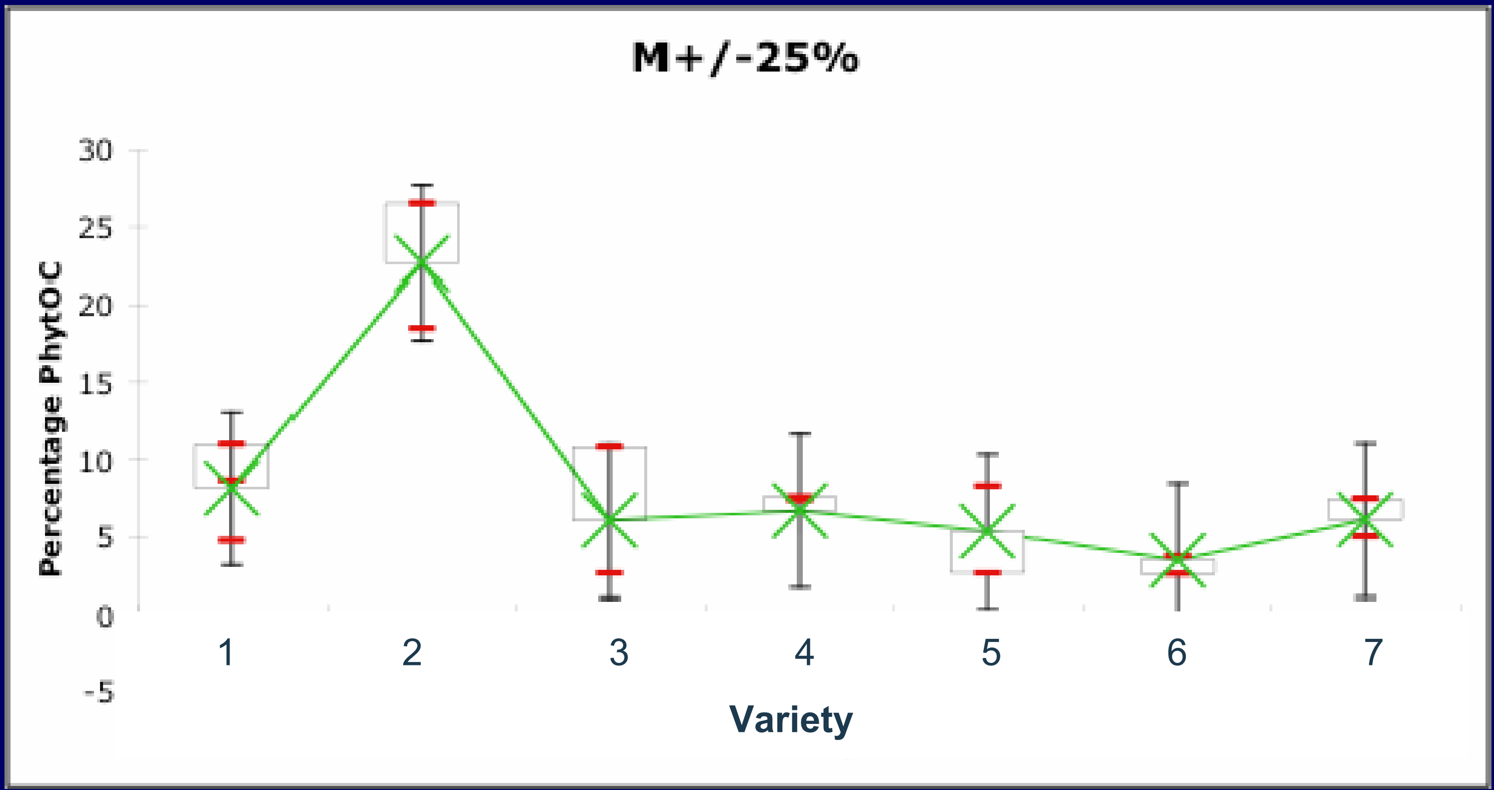
Faba Beans

Barley

Legumes

Mustard

Trials Tamworth NSW



With the exception of two varieties of one species the mean organic carbon locked up in Plantstones (PhytOC) ranged from 0.5% to 6% of Plantstone weight.

One variety of one cereal crop had PhytOC levels 5 times higher than other varieties of this crop.

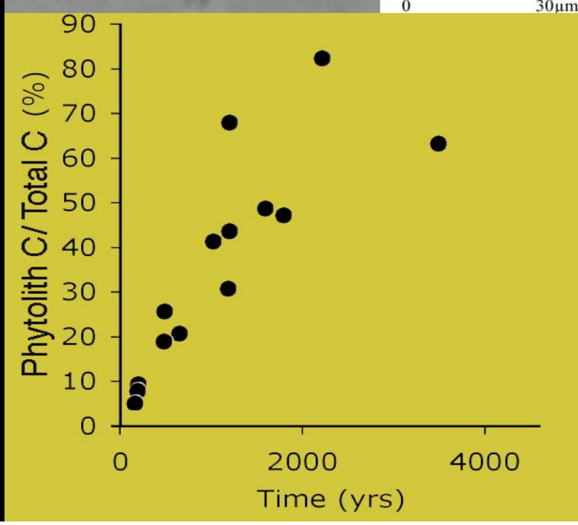
No apparent loss in grain or biomass yield.

Tall Wheatgrass and Salt Bush

PhytOC content for Tall Wheatgrass was 6% of Plantstone wt.

Change in vegetation & land-use + significant increases in long-term sequestered Plantstone carbon.

Picture supplied by George Truman Catchment Management Authority & Lachlan Rowling NSW Ag.



Summary

- *Many plants contain Plantstones i.e. phytoliths or plant opal*
- *Many Plantstones contain carbon*
- *Carbon in Plantstones is stored for thousands of years*
- *With no apparent loss in grain or biomass yield.*
- *Carbon stored in Plantstones can be used for the long term secure sequestration of carbon in agriculture and environmental remediation.*
- *Carbon sequestration in Plantstones can be optimized by selection of plant types or crop variety.*

Agricultural soils,

Acid sulfate soils,

Saline soils and,

Wetland areas

Plantstone

Research & Development

The next generation of Carbon Sequestration Solutions.