

Possibilities for Increasing Soil Carbon

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The Presentation

- The original talk prepared to address the practicalities of soil carbon sequestration
 - focused on where and how to increase soil organic matter (OM), and how to measure (verify)
 - looked at the requirement for OM rather than product sales
- Key issue: Compost production can never meet the requirement
 - recycling does not replace the inevitable losses
- Solution: use compost as a catalyst to stimulate the development of biologically functional soils

Relative Abundance of C (compared to the atmosphere)

1 ton C = 1.7 ton OM = 3.7 ton CO₂

- Carbonates ?
 - Fossil fuels > x 4
 - Soil OM x 1.9
 - Living x 0.7
- % decrease in Soil OM over 50 yrs 0.06 to 0.66

Levels of Soil OM



- 75% of agricultural soils < 1.75% OM
- Desirable OM levels, 2 to 4%
- Sequestration of carbon in soils:
 - Increase of 2% organic carbon to a depth of 30 cm, represents 35 tons C / ha or 128 tons of CO₂
 - Compares favourably with forestry
 - Can be achieved while improving the profitability of the existing land use

Main Effects of OM on Soils



- Increases the aggregation of soil particles
- Greatly increases the stability of aggregates
- From the above:
 - increases the permeability to air and water
 - usually increases the available soil water storage
 - decreases water loss through runoff and direct evaporation
- Increases the retention of nutrients
- Improves nutrient availability to plants (buffers a neutral pH)
- Provides food and a favourable environment for microbes
 - Increases nutrient recycling
 - Provides new nutrients (increases the nutrient supply)
 - Protect plants against pathogens

Social Benefits of increasing OM



- Improved use of water
 - increased productivity
 - resilience to drought
- Improved nutrition
 - increased food quality
 - reduced management inputs (fertiliser, pest control)
- Continue with existing land use
 - Improved profitability / sustainability
- Beneficial use of 'wastes'



Environmental Benefits of increasing OM

- Salinity
 - Reduces soil salinity by improving drainage
 - Improves plant nutrient uptake (neutral pH)
- Water
 - Likely improves the persistence and quality of accessions to streams
- Carbon sequestration
 - Potential to sequester large amounts of carbon
- Conservation of biota
 - Increased fertility
 - Reduced need for chemicals

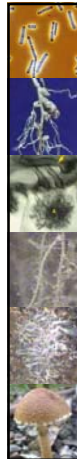


Political (carbon sequestration)

- Agricultural soil carbon increases permitted under Kyoto
- Carbon gains must be sustainable
 - 100% guarantee for 100 years
- For countries, carbon gains are referenced to 1990
- A trading system must exist
- Verification costs must be much less than the price paid for carbon

Forms and Longevities of Carbon

| Location | Form | Longevity | Level % of above ground biomass |
|----------------------------|--------------------------|-----------------------------|------------------------------------|
| Soil surface | Litter | days-years | 1-10 |
| | Roots | days-decades | 30-50 |
| Below Ground | Invertebrates | weeks-months | 0.01-10 |
| | Microbes | days-weeks | 0.01-100 |
| | Carbohydrates + Glomalin | days-weeks years-decades | 0.01-30 0.01-100 |
| Soil Organic Matter | Fulvic acids | years-decades | 0.01-100 |
| | Humic acids | 100-1000 years | 0.01-100 |
| | Humins | 100->1000 years | 0.01-100 |



Sequestration

- Only humic compounds and glomalin are long lived
 - Derive through soil microbiological activity
- Humic compounds around 70% of OM
- Glomalin around 30% of OM
 - The mass balance is invalid because glomalin has usually not been measured
- Around 10% conversion efficiency, organic matter to humic compounds

OM Measurement Issues

- Differentiation of forms of OM
 - Humic compounds and glomalin of interest
- Spatial resolution & averaging (x, y, z)
 - x, y scale relates to patterns of land use (tens of meters)
 - Z scale characterises soil profiles (cm)
- Other soil properties change with OM
 - Changes in bulk density and soil depth can affect estimates



Achieving Increases in Soil OM Controlling Factors

- Climate (temperature, rainfall)
 - Accumulation threshold 25 C. Increases 2-3 fold for each 10 C decrease in temperature.
 - Wet soils more than dry due to decreased aeration
- Vegetation
 - Grasses more than woody vegetation
- Soil Texture
 - Clays more than coarse textured soils (aeration, protection)
- Disturbance
 - Increased losses (aeration & temperature)




Site Selection

(carbon sequestration)


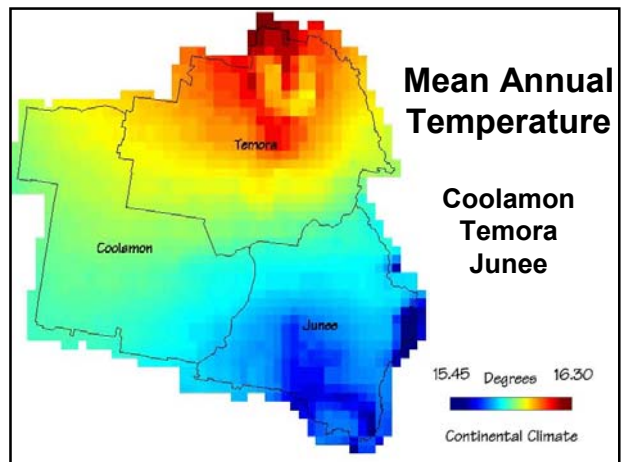
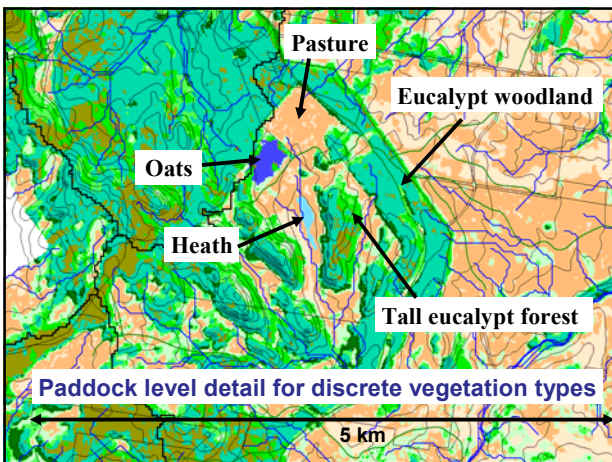
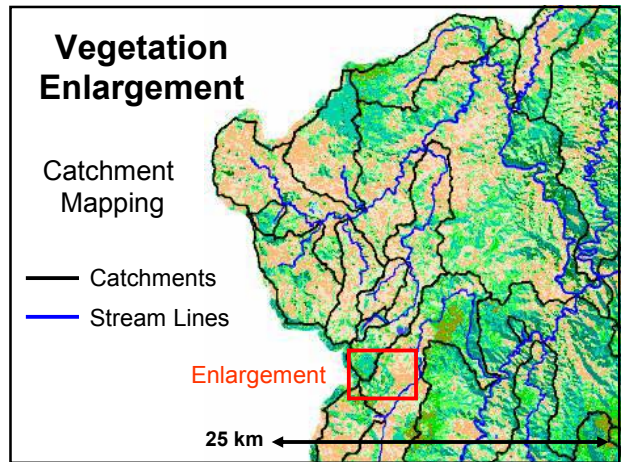
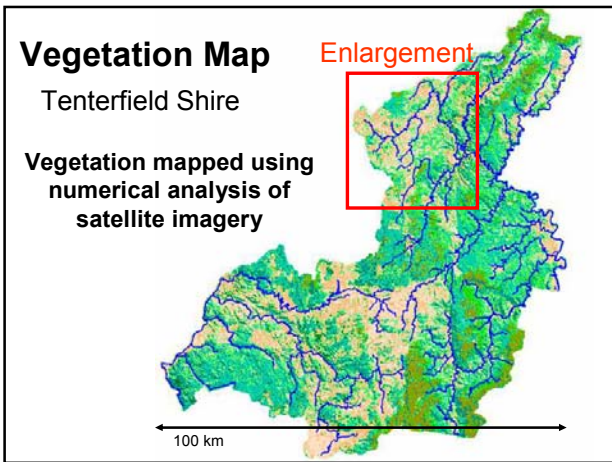
- Climate
 - Cool temperatures
 - Good rainfall
- Soil
 - Appreciable clay
- Site
 - Water accessions (run on areas)
 - Cleared land, preferably degraded

Situations where the accumulation of soil OM is most difficult are often where it is most needed



Use of Mapped Site Information

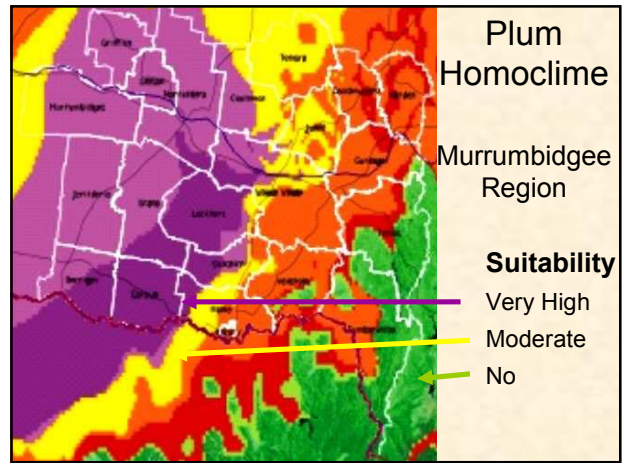
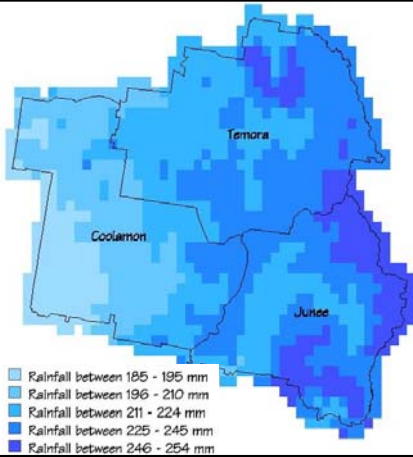
- Landcover / Land use
 - Identify available land
 - Estimate land condition
- Climate
 - Select appropriate regions
 - Select appropriate crops
- Soils
 - Select appropriate soils
 - Stratify measurements of soil OM

Growing Season Rainfall

(October to February)

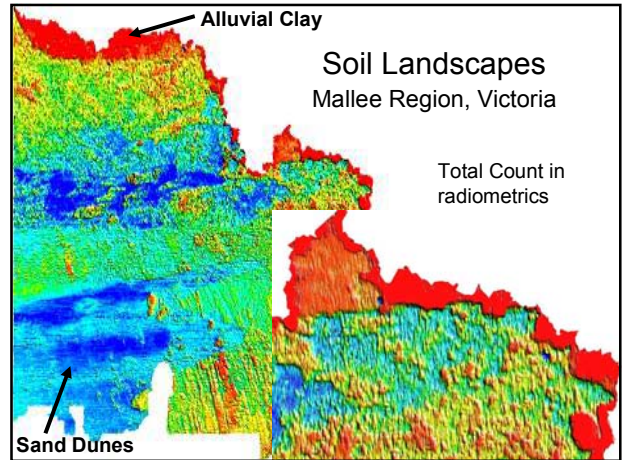
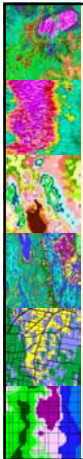
Coolamon, Temora, and Junee Shires



Soil Mapping

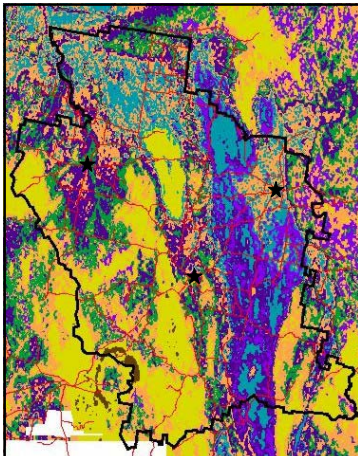
Soils largely determine the appropriate remediations and management

- Soil landscapes (traditional)
 - Map units represent mixtures of soils
- Optical imagery (Infra-red and thermal)
 - IR provides local patterns but only for bare soils
 - Surface measurement only
 - Thermal patterns less affected by land cover
- Gamma radiation emissions (radiometrics)
 - Field sampling according to mapped patterns
 - Paddock level detail with regional coverage



Texture

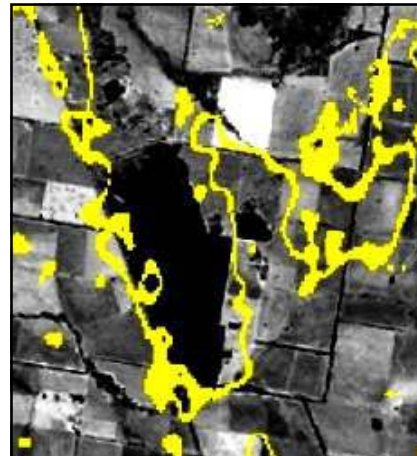
B2 Horizon
Cootamundra

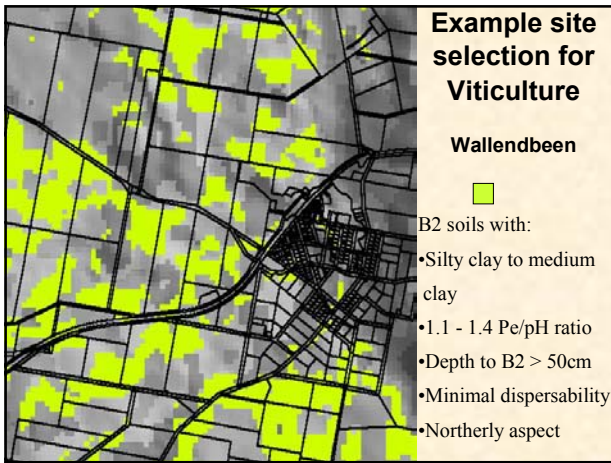


- Rock
- Sandy clay
- Silty clay
- Light clay
- Light to medium clay
- Medium clay
- Medium to heavy clay

Salinity

Surficial pathways





Issues with Application of Composts

- The supply of OM is much less than is needed
- Only around 10% of the applied OM provides long term gains

Heavy and ongoing applications of OM can be profitable, particularly where they address environmental degradation.

The need can be met by using the applied OM as a catalyst to promote the insitu development of soil OM

- Application of OM must be integrated with other aspects of land management so that the gains greatly exceed the applications

Management

- Minimise soil disturbance
 - (minimum tillage, cell grazing)
- Appropriate pastures and crop rotations
- Soil conditioning
 - (organic matter, microbes, minerals, ripping)
- Example systems
 - Yeomans keyline
 - Whittington interceptor banks (Witsalts)
 - Andrews Natural Sequence Farming (NSF)

Conclusions

A large potential exists to sequester OM in agricultural soils

- Sustainable gains in Soil C can be appreciable
- Agricultural soils are generally most suited
- Large areas of suitable soils exist
- The improvement in Soil OM improves:
 - the profitability of the existing land use
 - environmental outcomes
- Widespread implementation depends on cost effective methods

healthy soils AUSTRALIA healthysoils.com.au

- Healthy Soils Australia (HSA) is addressing the requirements to produce biologically functional agricultural soils by way of:
 - soil conditioning
 - soil measurement
 - soil, vegetation and land use mapping
 - mosaic land management
 - chain of ponds

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