Submission Number: 52
Date Received: 17/02/2014

Summary and Recommendations.

Revegetation and land use change over the savanna in Northern Australia is vital to sustainable natural resource management. Carbon sequestration from these activities could make a significant contribution to meeting Australia's Greenhouse Gas [GHG] pollution reduction goals. If the basic premise behind weed management strategies were to be changed to "harvesting" biomass to produce feedstock for pyrolysis, and/or input to a densified pellet production system, over time, not only would the need for weed control be reduced, but the biochar output from pyrolysis would improve soils and grow plantations suitable for inclusion in a biosequestration pool and the pellets produced could form the basis of a valuable rural export industry.

The GHG emissions profile of Northern Australia is unique. The potential exists to leverage off the leading edge land management practices to establish a carbon offsets industry that meets the needs of all the major polluters in the North. With the assistance of Regional Governments and active collaboration of the CDU Centre for Renewable Energy and Landcare, projects such as WALFA could be scaled up and sophisticated soil organic carbon measurement techniques refined to make Northern Australia a leader in carbon accounting and verified offset production.

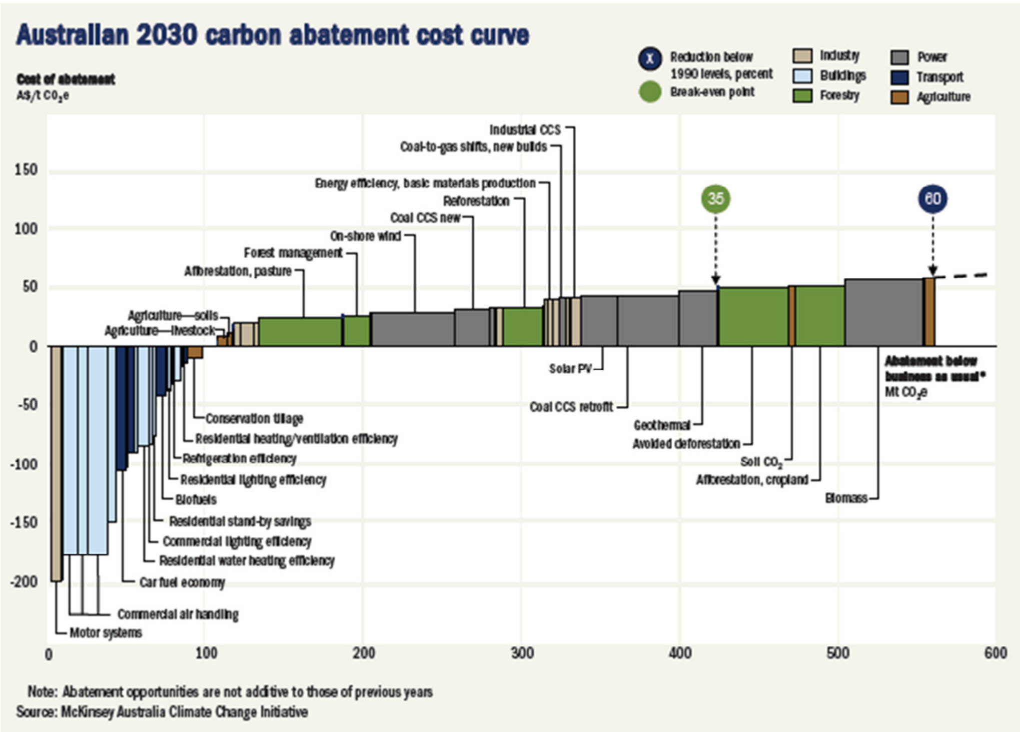
The Carbon Farming Initiative [CFI] funded by the Emissions Reduction Fund [ERF] will provide a source of domestic offsets under the National Carbon Offset Standard [NCOS]. The NCOS has been designed establish rules for pastoralists to become carbon neutral and provides guidance on what constitutes a genuine, additional voluntary offset. It sets minimum requirements for the verification and retirement of voluntary carbon credits and provides guidance for calculating the carbon footprint of an organisation for the purpose of achieving 'carbon neutrality'. The NCOS provides Australian agribusiness with the opportunity to develop offset credits for voluntary carbon markets including offsets from a range of land-based activities such as savanna management, revegetation and increased soil organic carbon from biosequestration. It provides for domestic offsets to be generated from abatement that is not counted towards Australia's Kyoto Protocol target.

Intermittent renewable power sources such as wind and solar have substantial disadvantages when compared to biomass, which is cost competitive, proven at both large and small scale and offers reliable base-load power supply. One of the key disadvantages of biomass as a renewable energy source is its high moisture content and bulky nature, which makes it expensive to transport over long distances and less efficient to combust than more concentrated energy sources such as fossil fuel.

However, the advent of torrefaction technology allows biomass to be dried and compacted into pellets which, in terms of calorific value, compare favourably with fossil fuels while being a renewable, climate friendly source. Increased use of biomass as a source of energy (electricity and heat) will contribute to the reduction of GHG emissions, increase energy security, and support sustainable development and regeneration of rural areas.

Amongst the conclusions reached in a 1998 study were *"….. that mimosa can be processed to produce a useful gas fuel, and that the gas can be converted to electricity using commercially available system components."* And, *"Australia stands to gain substantial rewards, including enhanced weed management outcomes, reduction of greenhouse gas emission, industry export activity, and **the biomass industry may do for the NT what the Snowy Mountains hydroelectric scheme did for Australia half a century ago**."(emphasis added).*

Biochar production and utilization differs from most biomass energy systems because the technology is carbon-negative: it removes net carbon dioxide from the atmosphere and stores it in stable soil carbon "sinks". Other biomass energy systems are ***at best*** carbon-neutral, resulting in no net changes to atmospheric carbon dioxide. Compared to more temperate climates, soil organic carbon [SOC] levels are relatively low in the sub tropical north.



Electricity generated as a by-product of the pyrolysis system and/or gasification of pellets can largely replace the petroleum diesel currently used on cattle stations and remote indigenous communities.

Recommendations.

[1] Immediate development of a new database on the soils above the 1000mm rainfall line that improves knowledge of the current and future land productivity as well as the present carbon storage and carbon sequestration potential. Derived from the soil database, CSIRO could produce a Carbon Map that allows for the identification of areas where soil carbon storage is greatest and the potential for sustainable growth of energy crops in degraded soils. Much of this information may already be available in CSIRO archives.

[2] The establishment of a Renewable Energy Association.

REA NA
RENEWABLE ENERGY ASSOCIATION

The Renewable Energy Association will represent Northern Australian renewable energy producers and promote a clean energy future in the North. Membership will cover the whole spectrum of renewables: electric power, heat and biofuels and represent a wide variety of organisations, including generators, project developers, fuel and power suppliers, equipment producers and service providers with representatives of all three levels of Government.

The REANA's main objective is to secure the best legislative and regulatory framework for expanding renewable energy production in the North. It will undertake policy development and provide input to government departments, industry associations, natural resource managers, NGOs and others.

The REANA will deal with broad renewables policies, but also cover sector specific issues. The intent is to establish a number of Sector Groups, some looking at individual technologies, others focussed on sub-sectors of the industry. The Association and the Sector Groups work in collaboration with other trade associations and NGOs.

[3] In association with an existing clean energy generator [e.g. Landfill Management Services[1]], build a pilot plant with combined torrefaction/pyrolysis processes to prove the economics of harvesting weeds and producing international quality densified pellets for export and biochar for soil improvement. Collateral with the above, determine the cost of producing carbon credits that meet NCOS guidelines.

[1] http://www.lms.com.au/

[4] Organize a consultative body incorporating NAILSMA, NLC, IBA and ILC to:

- Remove policy impediments to the evolution of a carbon economy in Northern Australia.
- Facilitation access to participation in carbon markets for Indigenous communities.
- Expand the "toolkit" of methodologies available for Northern Australia.
- Research how the policy environment might evolve such that the multiple set of benefits of land management approaches are recognised, beyond carbon abatement, to include wider biodiversity values, specific conservation goals, soil and water management, feral species management and Indigenous cultural values.

[5] Introduce a "burning off' levy based upon the amount of GHG emissions and reduction in SOC stocks. If however, a revegetation plan is produced that shows the native forest replaced with deep rooted perennial grass or other suitable energy crops, then the levy would be reduced by the carbon sequestration that results. Simultaneously develop a market mechanism that rewards land managers who use carbon neutral techniques such as pyrolysis to manage fuel loads in reducing the risk of uncontrolled wildfires.

GHG Emissions in the Northern Territory.

In 2007 Territorians emitted about 16.5 million tonnes of CO2e[2], however, on a per capita basis, Territorians are the biggest emitters in Australia by a significant margin and rank among the highest in the world. At nearly 65 tonnes the NT ranks with some of the oil producing countries in the Middle East. The NT's per capita carbon footprint is 140 per cent greater than the figure for Australia as a whole and 67 per cent higher than Queensland's, the next highest Australian jurisdiction (see Figure 2.1).

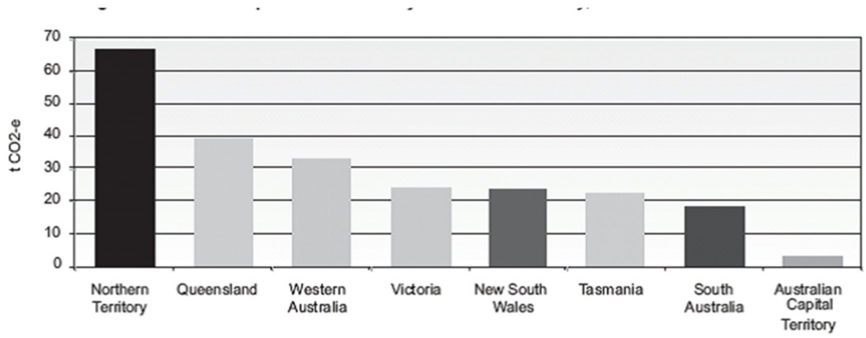


Figure 2.1 Per capita GHG emissions

Two of the reasons for the comparatively high footprint include:

- the fact that relatively few Territorians occupy a massive geographical area, with long distances between communities and over dependence on long haul transport to get mining and cattle exports to market, and
- a high rate of savanna burning, accounting for over a third [and in some years up to one-half] of the Territory's emissions.

This last point illustrates the fact that the Territory has a very different composition of its greenhouse gas emissions than Australia as a whole [see Figure 2.2] and reducing emissions from transport and savanna burning will have a disproportionate effect on total GHG emissions. Any processes that can economically address these two sectors will have the potential to produce very large quantities of marketable carbon instruments.

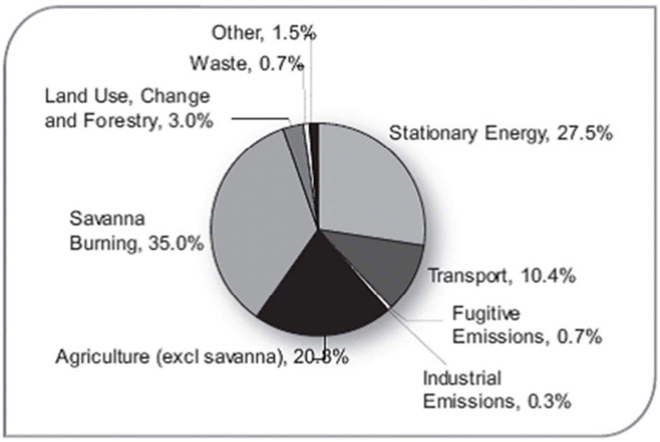


Figure 2.2 Northern Territory - emissions shares by sector, 2005

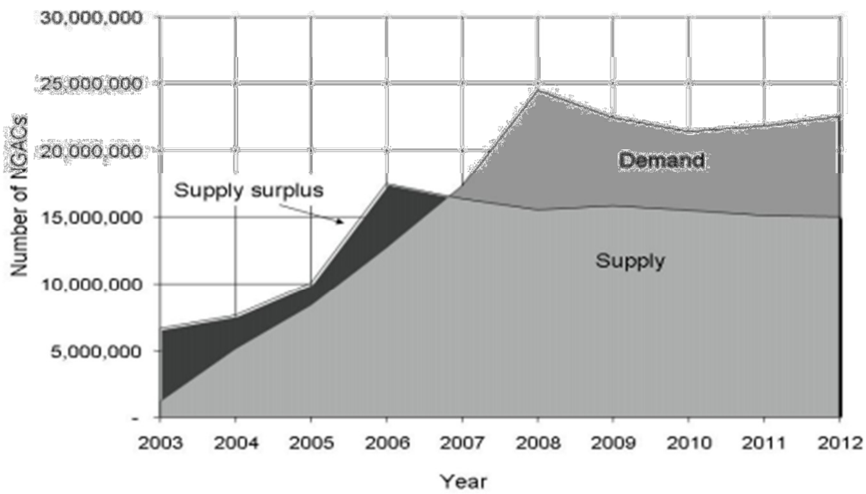
[2] The figures quoted here refer to 2007 and are taken from the National Greenhouse Gas Inventory published by the ***National Greenhouse and Energy Reporting System (NGERS)***

Compared to the other states the NT is unique in that it has very few industries that are energy intensive, high carbon emitters [although those that do exist, the miners ALCAN, GEMCO, MRM, etc. are huge] and a relatively large number of potential suppliers of carbon credits. The Conoco-Philips and INPEX gas plants at Wickham Point together will emit in excess of 11 million tonnes/p.a.[mtpa]. It is expected that, by 2020 GHG emissions in the NT will exceed 30 mtpa, and demand for carbon abatement certificates will far exceed supply. This is particularly so when the proposed Dow Chemical plant and Arafura Resources mill are built and the iron ore deposits at Roper Bar come on stream.

	Fuel Type	Fuel tonnes/a	Capacity MW	Electricity GWh	Electricity related GHG pollution	Total GHG pollution (t CO2 eq/yr)
Crocodile Gold	Gas		49			33,536
ERA	Diesel	23,500	26	87	59,347	237,388
GEMCO	Diesel	15,250	15	*60**	*30,000**	*65,000**
Newmont	Diesel	32,230		121.7	86,462	*130,000**
OM (Manganese)	Diesel	*32,000**	4	133.6	*85,000**	*130,000**
Rio Tinto Alcan	Bunker Oil	850,000	105	101.5		1,952,261
Xstrata	Gas		21	120.8	86,527	133,537
TOTALS		**952,980**	**220**	**625**	**347,336**	**2,681,722**

- **GHG Pollution and Electricity generation associated with NT mines.** Estimated
- **[Pacific Aluminium [RTA] at Nhulunbuy will decrease significantly in July 2014]**

Notwithstanding local demand there is no doubt that global demand for carbon credits [already evident in Europe and likely to emerge from China and India] will constantly exceed supply.



Source:

NSW GGAS – Demand/Supply of Gas Abatement Certificates, based on current accreditations and lodged applications.

BioSequestration

Since the advent of climate change due to an increase in carbon dioxide in the atmosphere, biosequestration had been recognised as a natural process that can be used to reduce GHG pollution.

There are a number of offset standards and offsets crediting mechanisms currently in operation including the Clean Development Mechanism under the Kyoto Protocol, the Voluntary Carbon Standard, the Chicago Climate Exchange, the New South Wales Greenhouse Gas Reduction Scheme [GGAS], the offset component of the Regional Greenhouse Gas Initiative [which operates in 10 northeast and mid-Atlantic states in the United States] and the Alberta Offset System. The Carbon Farming Initiative[3] will provide a source of domestic offsets under the National Carbon Offset Standard [NCOS]. Rather than establishing separate administrative arrangements to enable crediting for this 'non-Kyoto' abatement, carbon credits generated under the initiative will be recognised under the scheme.

A significant advantage of administering all eligible domestic abatement under the same scheme is that farmers will be able to bring forward projects, without having to first determine whether or not the abatement is recognised towards Australia's Kyoto Protocol target.

Natural resource management, carbon and savannas; an emerging issue for the 21st Century[4]. *"…. the relatively intact natural systems of the northern Australian savannas represent a natural asset of* global significance." They are being *"recognised as offering the greatest potential for cost effective resource management. For example, widespread savanna fire is the major source of global biomass burning and associated GHG emissions. Indeed in the NT, biomass burning contributes to ~ 50% of total GHG emissions.*

Nevertheless….savannas are net sequesters of carbon…and that sequestration potential can be increased by managing for reduced fire frequency. If grazing pressure from domestic livestock increases, then decreased grassy fuel load may reduce potential fire frequency."

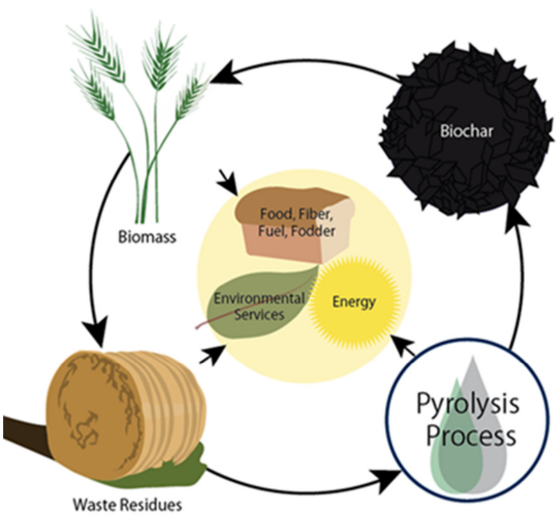
[3] http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative
[4] Carbon accounting, land management, science and policy uncertainty in Australian savanna landscapes: introduction and overview. Williams et al Australian **Journal of Botany** 2005 53 583 – 588.

Revegetation and land use change over large areas in the mid to low rainfall regions of Northern Australia in the form of savanna management and biosequestration is vital to sustainable natural resource management. Revegetation at the required scale is unlikely to occur with either public or private investment alone. Most options currently available to rangeland graziers and communities are not commercially viable - the costs exceed the direct benefits.

Many land management activities are likely to be commercially viable ***only*** if some value is attributed to the natural resource management (NRM) and GHG pollution mitigation benefits they deliver. Therefore, only new crop species and production systems that provide the cost effective opportunities for combined commercial and natural resource management benefits will be economically successful.

> *Increasing energy use, climate change, and carbon dioxide (CO_2) emissions from fossil fuels make switching to low-carbon fuels a high priority. Biofuels are a potential low-carbon energy source, but whether biofuels offer carbon savings depends on how they are produced. Converting rainforests, peatlands, savannas, or grasslands to produce food crop–based biofuels in Brazil, Southeast Asia, and the United States creates a "biofuel carbon debt" by releasing 17 to 420 times more CO_2 than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. In contrast, biofuels made from waste biomass or from biomass grown on degraded and abandoned agricultural lands planted with perennials incur little or no carbon debt and can offer immediate and sustained GHG advantages[5].*

Mature savanna landscapes aren't very good at sequestering carbon simply because in a balanced state decomposing detritus (bark, leaves and fallen trees) emits as much CO_2 as is absorbed by growing trees. A new growing forest sequesters much more CO_2 and, if suitable rotations are implemented, plantations can be harvested and replaced with growing trees on a regular basis, thus meeting the Kyoto protocols for permanence. To secure the commercial potential of tree crops planted to address land degradation from weed infestation, target products and markets must be selected so that appropriate cultivars can be chosen and planted. Wherever possible, market signals should be used to guide investment in tree crops.



[5] http://www.sciencemag.org/content/319/5867/1235.abstract

Agronomists suggest that a SOC of 2 – 4% is optimum for healthy soil capable of growing trees eligible for inclusion in a carbon sequestration pool. Regular addition of low cost biochar would simultaneously improve soils and create carbon credits.

An article by Christine Jones[6] reports that the Portuguese government introduced an AUD$13.8 million soil carbon offsets scheme based on dryland pasture improvement, compliant with Article 3.4 of the Kyoto Protocol's strict criteria of additionality and permanence. The scheme will pay an estimated 400 participating farmers to establish bio-diverse perennial mixed grass/legume pastures [upwards of 20 species] to improve soil carbon, soil water holding capacity and livestock productivity in an area of approximately 42,000 hectares.

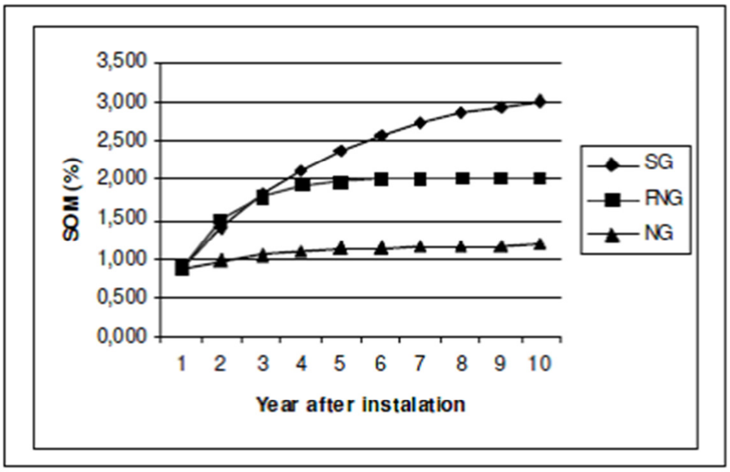


Fig. 2. Accumulation of soil organic matter (SOM), shown as percentage by weight, in soils under three pasture types.

SG = sown perennial pasture;
FNG = fertilised annual pasture;
NG = unfertilised annual pasture
(from Watson 2010).

The Portuguese soil carbon offsets project aims to sequester 0.91 million tonnes of CO_2 from 2010 to 2012 equating to the sequestration of 10.85tCO_2/ha/yr. In addition to the carbon payments they receive, participating Portuguese farmers are reported as *"enjoying the environmental spin-offs of greater biodiversity, higher soil fertility, higher water infiltration rates, less erosion, less desertification, fewer fires, less floods, improvement in water quality, less dependence on concentrated feed for their herds in protracted dry periods and better milk and meat quality".*

The proposed Emissions Reduction Fund is a perfect vehicle for supporting similar schemes in Northern Australia to be managed by Indigenous communities along the lines established by NAILSMA for the WALFA project.

6 http://permaculture.org.au/2010/07/22/soil-carbon-can-it-save-agricultures-bacon

Weed management.

Weed invasions pose a major threat to North Australian rangeland ecosystems. They threaten both individual native species and communities of native plants and animals, and they alter important ecological processes. More than 640 non-native naturalised plant species are found in the Australian rangelands and 14 per cent of these pose a serious threat to rangeland biodiversity.

Expenditure on weed management in the rangelands between 1997 and 2004, most of which was sourced from the Natural Heritage Trust, is estimated at $80 million[7]. Currently weed control is seen as an expensive exercise endlessly repeated with little hope of ever completely solving the problem.

Estimated cost of stand-by equipment for fire ban days (per year)

	Grass Fuel Loads		
	$6\ t\ ha^{-1}$	$10\ t\ ha^{-1}$	$15\ t\ ha^{-1}$
2008	$125,862	$766,614	$1,407,366
2009	$57,210	$434,796	$1,086,990

Data in 2010 dollars. Costs do not include staffing costs.
doi:10.1371/journal.pone.0059144.t004

Agronomists will confirm that weeds are opportunistic and can be controlled best by growing healthy plants in healthy soils.

If the basic premise behind weed management plans were to be changed to “harvesting” weeds to produce feedstock for a pyrolytic process, over time, not only would the need for weed control be reduced, but the biochar output from pyrolysis could be used to improve soils and grow plantations suitable for inclusion in a carbon sequestration pool [CSP].

Burning Gamba Grass in the Northern Territory.

One of the major problems with using fire management solely is the risks associated. For instance, an article by Vanessa M Adams and Samantha A Setterfield[8] states:

> *Our analysis demonstrates that the presence of gamba grass seriously impacts the financial viability of savanna burning projects. For example, in order to recuperate the annual costs of controlling 1 ha of gamba grass infestation, 290 ha of land must be enrolled in annual carbon abatement credits. Our results show an immediate need to contain gamba grass to its current extent to avoid future spread into large expanses of land, which are currently profitable for savanna burning.*

[7] Source: CRC for Australian Weed Management. Grice, A. C. and Martin, T.G. 2005.
[8] http://iopscience.iop.org/1748-9326/8/2/025018/article

Strategies to manage problems caused by weeds aim to prevent, eradicate, contain or control the weeds. It is unlikely, however, that any rangeland weed problem can be solved with one-off treatments using a single technique. Rather, a strategic approach that effectively integrates innovative technologies such as pyrolysis is required. Integrated weed management combines chemical, mechanical and biological options - the combination used depends on the biology of the weed(s) and the circumstances under which it is growing. Each control technique has potential side effects for native flora and fauna. Clearly, a particular weed management regime must produce a better outcome for biodiversity than the weed invasion itself.

In 1998 a consortium of NT Government Departments, Power and Water Corporation and private enterprise pooled resources to investigate various techniques for using *Mimosa pigra* as a fuel for the production of electricity and charcoal. The project was the subject of a case study; ***The potential use of mimosa as fuel for power generation[9].***

The research indicated that *"…. a kilogram of air dried mimosa biomass has a net calorific value of 17.7 MJ. The gasification process is around 75% efficient, including losses due to unreacted char, with producer-gas having a typical calorific value of around 5,000 kJ/m^3. Conversion of that gas to electricity, at say 36% efficiency, produces around 1.25 kWh of electricity/kg dry biomass. It is estimated that there is sufficient Mimosa pigra to keep a five to eight megawatt power station running for 15 years."*

Amongst the conclusions reached were *"We have established that mimosa can be processed to produce a useful gas fuel, and that the gas can be converted to electricity using commercially available system components."* And*, "Australia stands to gain substantial rewards, including enhanced weed management outcomes, reduction of greenhouse gas emission, industry export activity, and* ***the biomass industry may do for the NT what the Snowy Mountains hydroelectric scheme did for Australia half a century ago."****(*emphasis added*).*

The project exposed the limitations of raw feedstock in the pyrolysis process. However, since 1999, significant advancements have been made in feedstock pre-processing which overcome all the limiting factors experienced in the experiment.

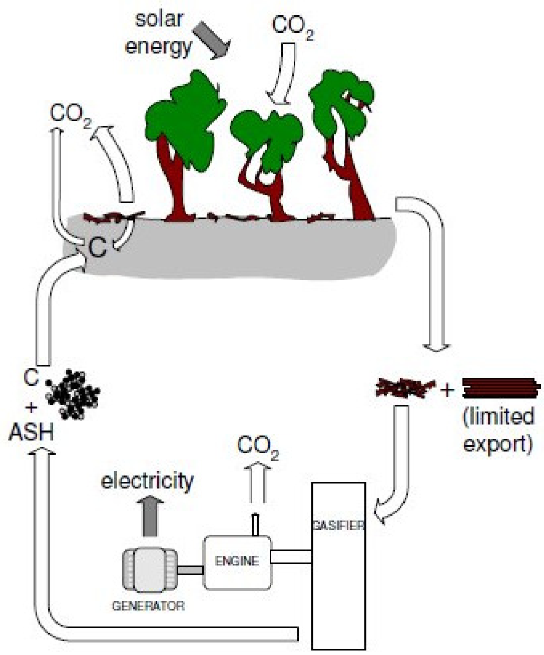
[9] Keith Presnell NT Centre for Energy Research, Charles Darwin University,

With the use of torrefaction, significantly lower energy is require to process the raw feedstock and the modified fuel can be compacted into high grade densified pellets with substantially superior properties that meet international quality standards.

Densified Pellets.

There are a number of obstacles to overcome in order to expand the biomass sector and the use of biofuels. Whilst some of these include bureaucracy, economics and fragmented approaches from regional and national authorities, there are also limitations associated with biomass fuel properties.

Direct comparisons of biomass with coal, still the dominant solid fuel in electricity and heat generation, often reveal inferior properties of biomass. In particular, it has lower energy densities, is a bulkier fuel (with poorer handling and transportation characteristics), more tenacious (its fibrous nature means it is difficult to reduce to small homogeneous particles) and – in most cases – a higher moisture content, resulting in storage complications such as degradation and self heating. These properties can have negative impacts during energy conversion such as lower combustion efficiencies and gasifier design limitations.

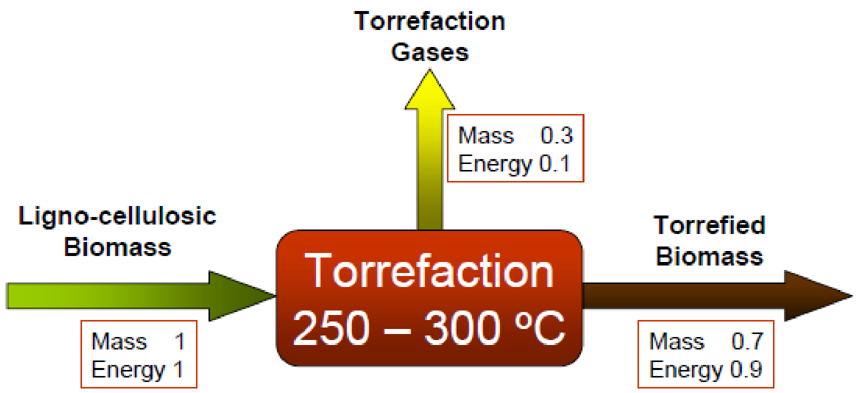


Torrefaction[10] is a thermal treatment that occurs in an inert atmosphere. It removes moisture and low weight organic volatile components and depolymerises the long polysaccharide chains, producing a hydrophobic solid product with an increased energy density (on a mass basis) and greatly increased grindability. As a result, significantly lower energy is require to process the torrefied fuel and it no longer requires separate handling facilities when co-fired with coal in existing power stations.

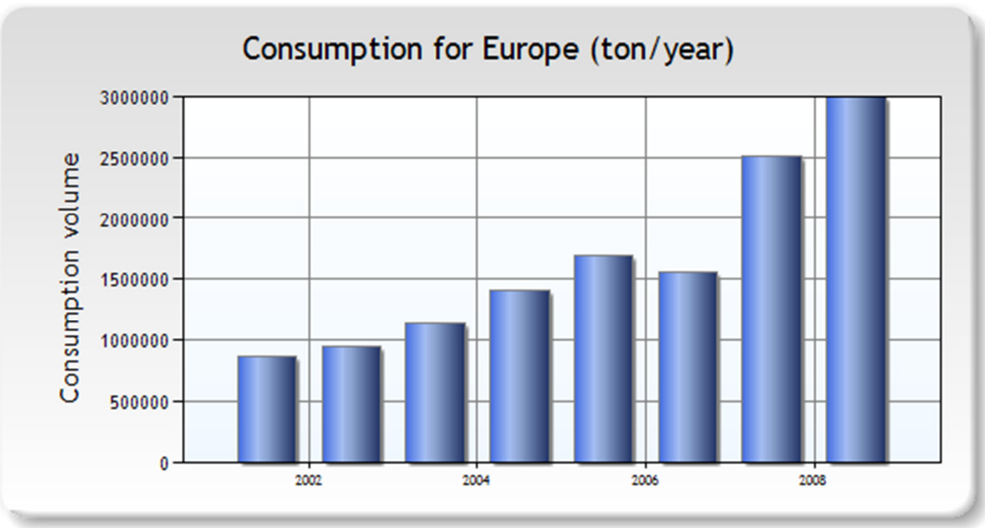
The modified fuel can be compacted into high grade pellets with substantially superior properties when compared with standard wood pellets. The process can be incorporated into a combined drying, torrefaction and pelletisation process, with both economic and energy efficiency benefits.

[10] www.srs.fs.fed.us/pubs/ja/2010/ja_2010_mitchell_001.pdf

Finally, it has been suggested that torrefied biomass is a suitable feedstock for entrained flow gasification, systems previously not considered feasible for raw biomass solid fuels. This is because torrefied biomass forms more spherical shaped particles during grinding or milling. However, the process requires a separate plant, an input of process energy and the production of gaseous and volatile streams, entailing capital costs, operating costs and emission control. The balance between these associated costs and energy consumption and the cost and energy benefits from a more grindable, higher calorific value fuel are therefore critical for the future of torrefaction and require thorough analysis and reliable, extensive data.



Torrefaction has only received significant interest in the last two decades, and has yet to become a commercial process. The majority of research to-date has focused on the compositional changes that occur in biomass and energy yields. Some studies have also investigated the composition of volatile matter released during the process. This previous work has focused primarily on woody biomass, including the comparisons of softwoods and hardwoods .



There is a compelling business case for biopellets as a clean renewable fuel for distributed electricity generation in regional and remote Northern Australia.

- ❖ Wood pellets are a well established solid fuel
- ❖ The technology for generating electricity from wood pellets is mature and efficient
- ❖ Pellets are price competitive with diesel when oil costs more than US$75 /barrel, reaching €400 pt in Europe.

The major barrier to the development of a biomass energy industry in the North is the risk associated with long term supplies of suitable feedstock. This uncertainty could be overcome by simultaneous development of a number of sources including:

- ❖ Harvesting of weeds such as Mimosa pigra.
- ❖ Growing ‘energy crops’ including perennial grasses and acacia mangium plantations.

The establishment of a commercial pellet plant can only proceed based upon a reliable assessment of the feedstock resource available. Such analyses are available at: *Assessment of Australia biomass for producing bioelectricity and biofuel and reducing greenhouse gas emissions database.*

And another CSIRO product called SOILMAPP can be used to:

- ❖ learn about the soil on a property
- ❖ view maps, photographs, satellite images and data about local soils
- ❖ uncover a soil’s physical and chemical characteristics, including acidity (pH), soil carbon, water storage capacity, salinity and erodibility
- ❖ help manage non-irrigated crops and develop input data for yield prediction.

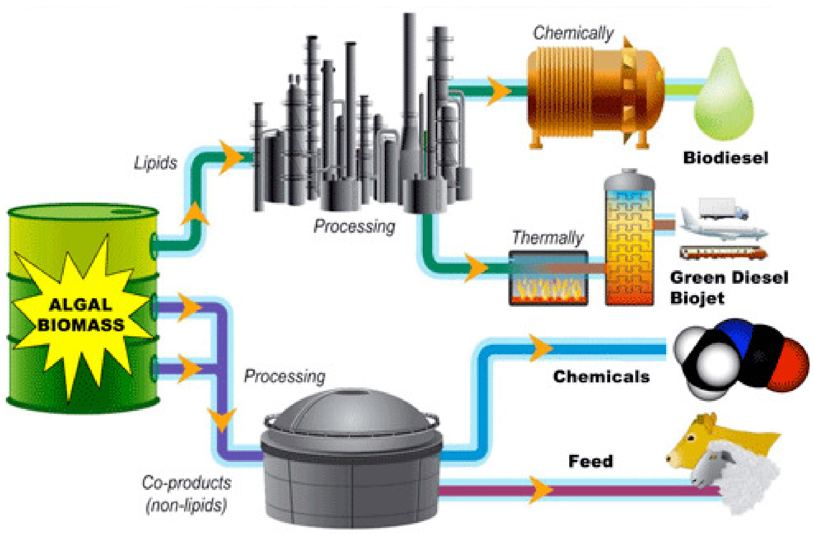
New feedstock production systems.

There are many new biomass or oil production systems proposed for energy. In addition to serving as a resource of energy, new production systems may provide both positive and negative collateral impacts once established. This is particularly the case for broad-acre systems such as woody crops. Positive impacts may include restoration of biodiversity and reduction in salinity; they may bring economic benefits in areas of low agricultural value, diversification of the rangeland enterprise may help manage the financial risk, and they provide long-term stability to sustain systems with high inter-annual variation in production.

Algae holds promise to contribute significantly to biofuel production using both the oil component and bioelectricity from the remaining biomass once the oil is removed[11].

Table 4 Estimated theoretical *Area* and *Annual production* of future dedicated energy biomass production systems when they have been fully established

Feedstock	Area ('000 ha)	Annual production (dry kt)	Harvest (dry kt)
Algae biomass	80	8000	8000
Coppice eucalypt	2287	14 996	14 996
Pongamia seed	458	2950	2950



Conceptual investment framework for biofuels & biorefineries R&D **Special Report**

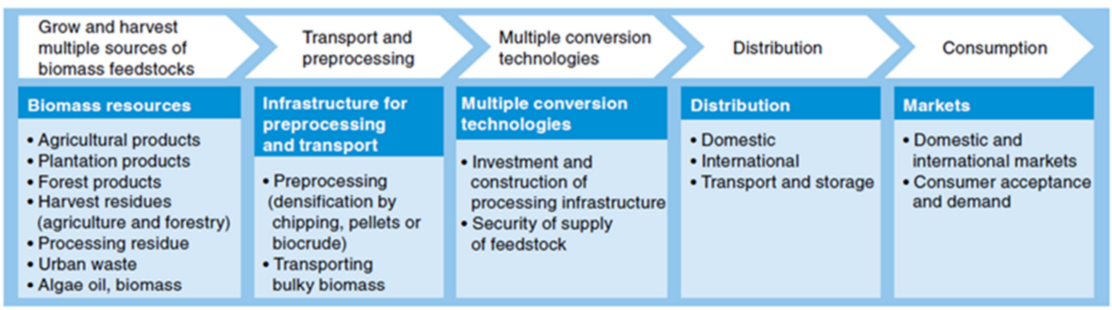
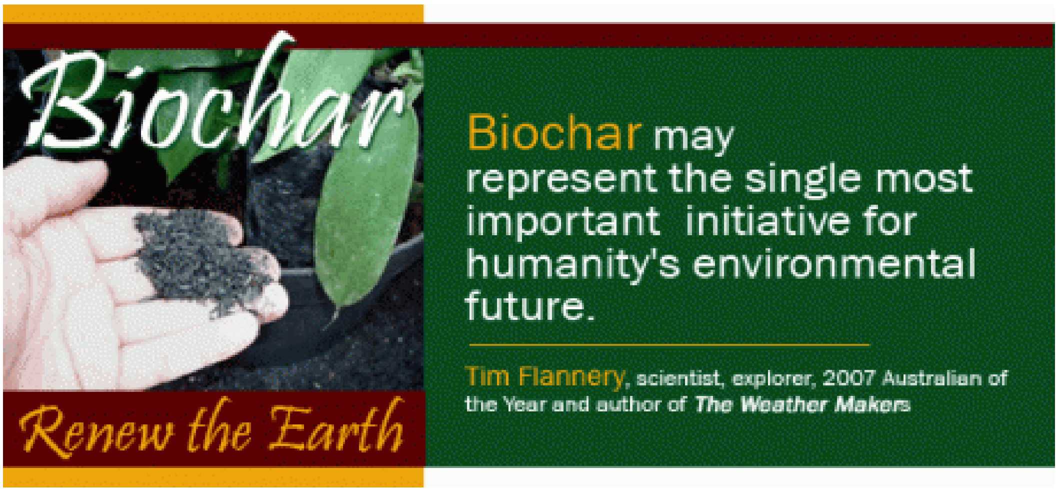


Figure 1. Generic value chain for biofuels, showing the main elements of biomass production and harvest, transport and biofuel manufacturing into different product streams for domestic and international markets.

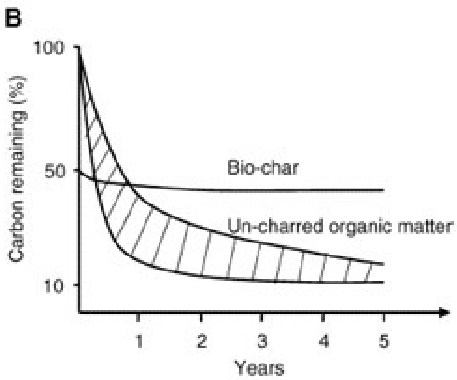
[11] An assessment of biomass for bioelectricity and biofuel, and for greenhouse gas emission reduction in Australia
http://www.researchgate.net/profile/Alexander_Herr2/publication/230482464_An_assessment_of_biomass_for_bioelectricity_and_biofuel_and_for_greenhouse_gas_emission_reduction_in_Australia/file/60b7d52842cfae53ad.pdf

Biochar.

Biochar and bioenergy co-production from agricultural biomass can help combat global climate change by displacing fossil fuel use, by sequestering carbon in stable soil carbon pools, and by dramatically reducing emissions of nitrous oxides, a more potent greenhouse gas than carbon dioxide.[12,13]



As a soil amendment, biochar helps to improve soil by increasing crop yields and productivity, by reducing soil acidity, and by reducing the need for some chemical and fertilizer inputs.[14,15]



Water quality is improved by the use of biochar as a soil amendment, because biochar aids in soil retention of nutrients and agrochemicals for plant and crop utilization,[16,17] reducing leaching and run-off to ground and surface waters.

[12] Yanai et al., 2007, Effects of charcoal addition on N2O emissions from soil resulting from rewetting air-dried soil in short-term laboratory experiments, ***Soil Science and Plant Nutrition***, 53:181-188.
[13] Rondon, M., Ramirez, J.A., and Lehmann, J.: 2005, Charcoal additions reduce net emissions of greenhouse gases to the atmosphere, in ***Proceedings of the 3rd USDA Symposium on Greenhouse Gases and Carbon Sequestration***, Baltimore, USA, March 21-24, 2005, p. 208.
[14] Glaser, B., Lehmann, J. and Zech, W., 2002, Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal --- a review, ***Biology and Fertility of Soils***, 35: 219-230.
[15] Lehmann, J. and Rondon, M., 2006, Agrichar soil management on highly weathered soils in the humid tropics. In Uphoff N (ed.), ***Biological Approaches to Sustainable Soil Systems***, CRC Press, Boca Raton, FL, pp. 517-530.
[16] Lehmann, J., et al., 2003, Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments, ***Plant and Soil***, 249: 343-357.
[17] Steiner, C., et al., Long term effects of manure, charcoal and mineral fertilization on crop production and fertility on a highly weathered Central Amazonian upland soil, ***Plant and Soil***, 291: 275-290.

Biochar production and utilization systems differ from most biomass energy systems because the technology is carbon-negative: it removes net carbon dioxide from the atmosphere and stores it in stable soil carbon "sinks".[18] Other biomass energy systems are *at best* carbon-neutral, resulting in no net changes to atmospheric carbon dioxide.

Bioenergy and biochar can be co-produced from thermal treatment of biomass feedstocks. The thermal conversion of biomass, under the complete or partial exclusion of oxygen, results in the production of biochar, energy (electricity and heat) and other products. Biochar production processes can utilize most agricultural or forestry biomass residues, including wood chips, tree bark, animal manure, and, most importantly, a wide variety of weeds.

Under controlled production conditions, the carbon in the biomass feedstock is captured in the biochar and the bioenergy co-products. Theoretically, the biochar co-product will retain up to 50% of the feedstock carbon in a porous charcoal structure; and the remaining 50% of the feedstock carbon will be captured as energy. Pyrolysis systems produce biochar largely in the absence of oxygen using some of the energy generated as an external heat source to dehydrate the feedstock.

Pyrolysis production systems can be developed as mobile or stationary units. Small scale gasification and pyrolysis systems that can be used on farm or by small industries are commercially available with biomass inputs of 50 kg/hr to 1,000 kg/hr. The bioenergy produced from these systems, which can be in the form of a synthetic gas, or syngas, or bio-oils, can be used to produce heat, power or combined heat and power.

Biochar is a fine-grained, porous charcoal substance that, when used as a soil amendment in combination with sustainable production of the biomass feedstock, effectively removes net carbon dioxide from the atmosphere. In the soil, biochar provides a habitat for soil organisms, but is not itself consumed by them to a great extent, and most of the applied biochar can remain in the soil for several hundreds to thousands of years[19],[20].

[18] Lehmann, J., Gaunt, J., and Rondon, M., 2006, Bio-char sequestration in terrestrial ecosystems – a review. Mitigation and Adaptation Strategies for Global Change, 11:403-427.
[19] Pessenda, L.C.R., Gouveia, S.E.M., and Aravena, R., 2001, Radiocarbon dating of total soil organic matter and humin fraction and its comparison with ^{14}C ages of fossil charcoal, ***Radiocarbon***, 43: 595-601.
[20] Schmidt, M.W.I., Skjemstad, J.O., and Jager, C., 2002, Carbon isotope geochemistry and nanomorphology of soil black carbon: Black chernozemic soils in central Europe originate from ancient biomass burning. ***Global Biogeochemical Cycles***, 16: 1123.

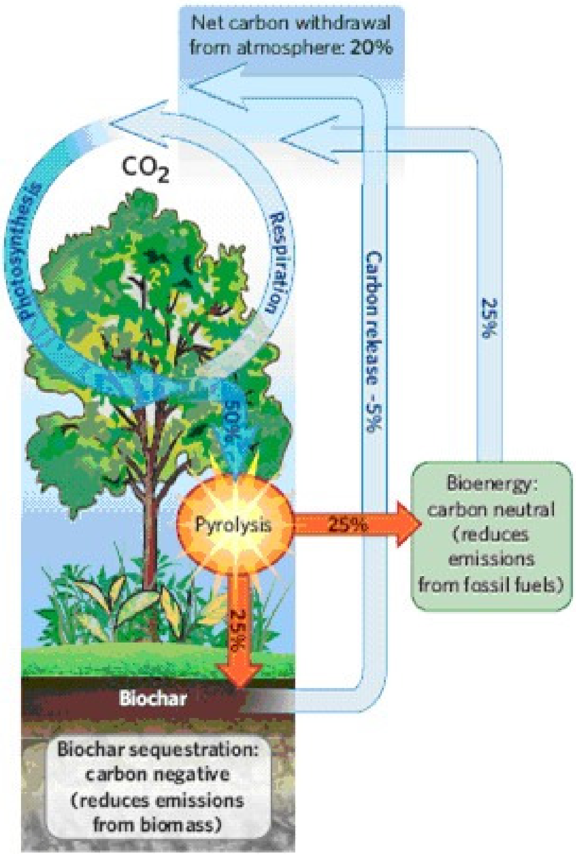
The biochar does not in the long-term disturb the carbon-nitrogen balance, but holds and makes water and nutrients available to plants. When used as a soil amendment along with organic and inorganic fertilizers, biochar significantly improves soil tilth, productivity, and nutrient retention and availability to plants.[21]

Economics of Biochar Systems

The co-production of biochar from biomass feedstock reduces the total amount of bioenergy that is produced by the technology, but even at today's energy and fertilizer prices the net gain in soil productivity is worth more than the value of the energy that would otherwise have been derived from the biomass feedstock. As the cost of carbon emissions rises and the value of CO_2 extraction from the atmosphere is also considered, the balance becomes overwhelmingly attractive in favor of biochar co-production.

When it comes to including biochar in emissions trading schemes, accountability is more straightforward than with other soil sequestration methods. Both the conversion of biomass into biochar and its application to soil are readily monitored, without additional costs. No complex predictive models or analytical tools are required, as is the case with other soil sequestration approaches. The source of biochar additions can easily be identified by soil analyses, if desired for verification under carbon-trading schemes.

Tracing the source of carbon in soil back to a change in agricultural practice, or other photosynthetic source, is much more difficult, and therefore currently not accepted under the Kyoto Protocol. Because these barriers do not exist for biochar sequestration, there is no reason why the associated emission reductions should not be allowed into trading markets under current agreements.



Source: J. Lehmann, "A Handful of Carbon," 2007. Nature 447, pp. 143-144.

[21] Glaser, B., Lehmann, J. and Zech, W., 2002, Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal --- a review, ***Biology and Fertility of Soils***, 35: 219-230.

Sequestering carbon in soils and vegetation.

Although vegetation biomass density in the north is generally low, the vast areas mean that around 30% Australia's stored carbon lies in the soils, vegetation and vegetation residues (35.9, 7.7 and 0.8 Gt of C respectively), more than 300 times Australia's annual emissions (Fig. 2).

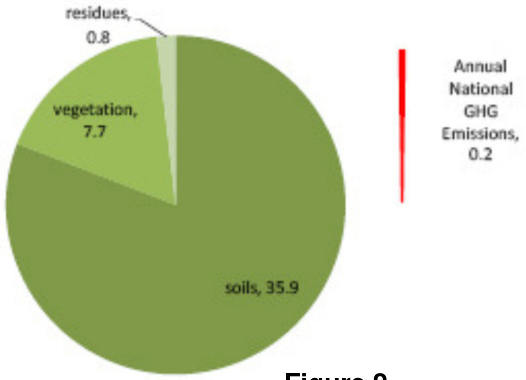
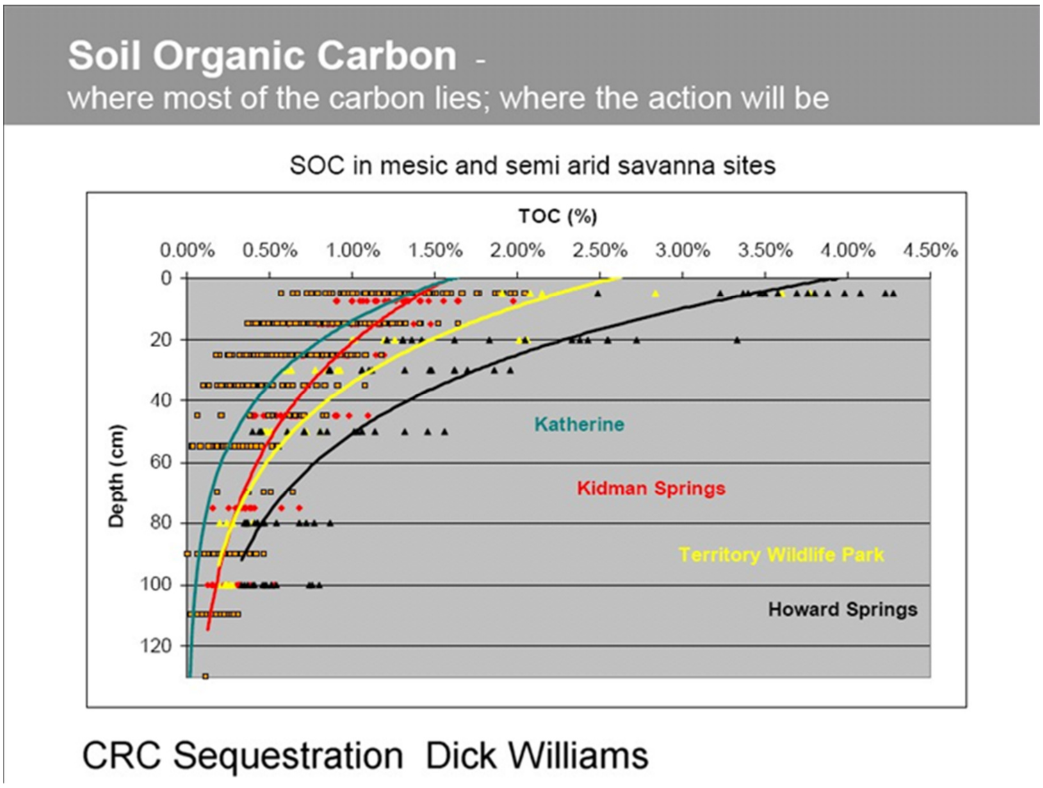


Figure 2

Modelling (at the regional level) suggests that carbon stocks in vegetation in northern Australia range from 1 t/ha (e.g. in the Simpson Desert and skeletal soils of the northern Kimberley) to 70 t/ha (in the Brigalow belt and mulga lands of Queensland and the savanna forests around Darwin and the Tiwi Islands).



Estimates of soil carbon stocks (0–30 cm depth) in northern Australia range from 1 to10 t/ha in more arid regions to 40 to 50 t/ha in more mesic regions . Small changes to this store can either contribute markedly to Australia's abatement efforts or overwhelm other abatement activities.

Carbon Farming – an opportunity for Indigenous Communities.
[derived from http://www.regional.gov.au/regional/ona/carbon-economy-for-northern-australia-2012.aspx see Appendix A]

The potential benefits of Northern Indigenous communities participating in carbon offset schemes could be significant, improving the social and economic well-being of local communities, and contributing to the sustainability of Indigenous livelihoods.

Carbon economic development activities that support Indigenous peoples' cultural, social and environmental priorities can also provide benefits for the broader Australian community through mutual cultural exchange, capacity building, the protection of biodiversity and the achievement of sustainable land management. Industries based around natural ecosystems, including tourism, fisheries, timber, water and bush foods, are currently an important part of the northern Australian economy. Many management changes inherent in the realising the carbon-economy for Northern Australia will enhance these industries, or at worst have an overall neutral effect.

Reducing Emissions from Savanna burning.

Much of the savannah ecosystem in the North burns frequently, contributing ~ 9Mt per year to the national emissions account. These emissions represent a potential abatement market of as much as $200M per year.

The vast tropical savanna landscapes that dominate the northern third of Australia constitute one of the most fire-prone biomes on Earth. Fire is a routine part of the annual wet/dry cycle of this part of the world, burning more than 400,000 Km^2 each year.

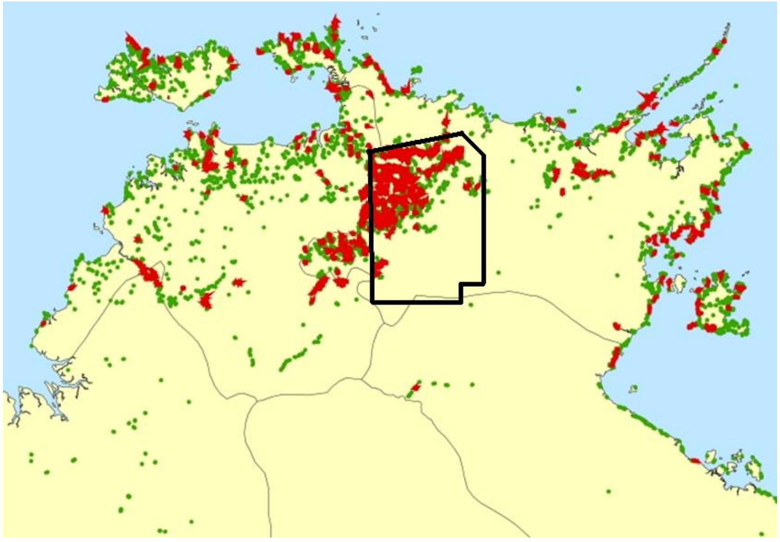
These fires release into the atmosphere large quantities of the greenhouse gases methane and nitrous oxide, with savanna burning contributing on average about 2% of Australia's total greenhouse gas emissions. The majority of northern Australia is extremely remote and sparsely populated; fire is largely unmanaged. Most emissions from savanna burning are generated by relatively high intensity wildfires that sweep through extensive areas during the end of the dry season in September and October.

These wildfires also threaten important components of Northern Australia's biota. There is particular concern that unmanaged fire is contributing to the dramatic declines in small mammal populations that have occurred across northern Australia in recent decades. Better management of fire to reduce wildfire risk is a prerequisite for most other land uses, whether for orthodox production or biological and cultural values.

Savanna burning for greenhouse gas abatement can therefore have important biodiversity co-benefits. It can also have important cultural and economic benefits for remote Aboriginal communities, which represent Australia's most socially disadvantaged sector and where mainstream economies are very limited. Landscape burning has been an integral part of Aboriginal culture in northern Australia for tens of thousands of years. Customary burning practices have been severely disrupted following European colonisation, and most Aboriginal people have moved off their traditional homelands to coastal towns and other settlements.

However, much traditional ecological knowledge relating to fire has been retained, and many Aboriginal elders have a strong desire to fulfil their cultural obligations by re-establishing traditional fire management on their homelands. The emerging carbon economy provides an opportunity for developing cultural appropriate Indigenous livelihoods that make nationally significant contributions to greenhouse gas abatement and biodiversity protection.

Estimates from the West Arnhem Land Fire Abatement [WALFA] project indicated abatement of 0.04 t CO_{2-e} ha-1 yr-1 and other studies suggest that higher abatement may be attainable elsewhere. Up to 51M ha has been identified where returns will exceed costs. This would abate in the order of 1.6 Mt CO_{2e} yr. Larger areas could be brought under management if carbon incomes were combined with public support for nationally and regionally significant environmental outcomes.



This opportunity has already been realised in the form of the WALFA project, which commenced in 2004 with AUS$17 million funding from energy company Conoco-Phillips and has generated more than 100 000 t CO_{2e} abatement annually. Aboriginal traditional owners and ranger groups are employed to undertake prescribed burning early in the dry season, which limits the extent of unmanaged wildfires later in the season, and thereby reduces overall greenhouse gas emissions and protects the biodiversity values of adjoining Kakadu National Park. It has led to important cultural enrichment for Aboriginal people, reconnecting them to their traditional homelands, rekindling interest in traditional ecological knowledge, and providing opportunities to pass on this knowledge to younger generations. The current CFI approved Savanna Burning methodology applies to higher rainfall regions (>1000 mm p.a.) but has potential to be extended to lower rainfall conditions (600–1000 mm p.a.).

As the SGS Economics and Planning Submission points out;

> *It is incumbent on all levels of government and infrastructure agencies and enterprises to ensure that Aboriginal and Torres Strait Islander people are effectively engaged and consulted in the planning, design, delivery, operation and maintenance of essential and municipal infrastructure in their communities. The problem is not the ownership of the land as such, nor the possible existence of native title rights and interests, but rather where the responsibility for the ownership, operation and maintenance of the infrastructure asset lies and how that will be paid for and maintained and managed over time, and how remote Indigenous communities may be able to utilise the value of their land to create revenue and economic opportunities.*
>
> *Further land tenure reforms to the Aboriginal land regimes in the various jurisdictions, and amendments to the Commonwealth's Native Title Act to enable native title holders to realise economic development opportunities on their land without having to extinguish their native title rights and interests, need to be pursued.*

REVEGETATION NOT CLEARING.

A NCAS 1999 report clearly stated –

> *"There are no standard data to estimate the impacts of various land-use practices on soil carbon inventories, and each country is expected to derive its own from long-term field experiments or other soil and agricultural production studies. Default values have been provided for the relative changes in soil C stocks per m^2 at equilibrium following the imposition of several land uses and land management practices[22]."*

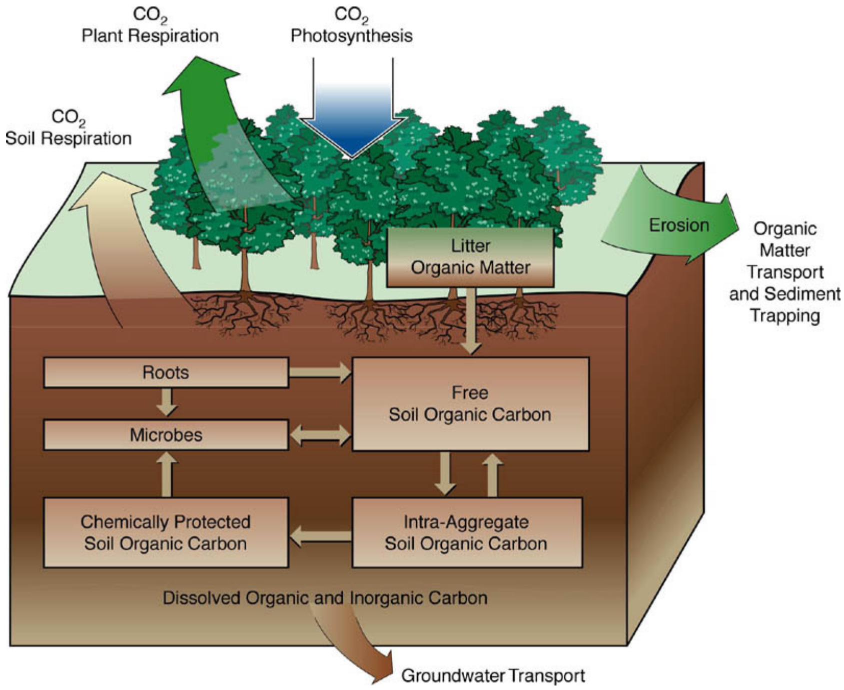
Until now, most efforts to use agriculture to manage greenhouse gases have involved above-ground sequestration, primarily through planting trees, since the amount of carbon that can be sequestered in this way is substantial. However, there is also growing interest in finding ways to increase carbon sequestration in soils. Soils are presumed to be the largest carbon reservoir of the terrestrial carbon cycle, although estimates of their magnitude vary widely. Soil can be a source or a sink for green house gases depending on land use management. For long-term sequestration, organic carbon must be stored in forms and in locations in the soil profile with slow turnover.

Mature savanna landscapes aren't very good at sequestering carbon simply because in a balanced state decomposing detritus (bark, leaves and fallen trees) emits as much CO_2 as is absorbed by growing trees. Growing vegetation sequesters much more CO_2 and, if suitable rotations are implemented, woodlots and pastures can be harvested and replaced on a regular basis, thus meeting the Kyoto protocols for permanence.

There is no valid reason for the NT pastoral sector to be a net emitter of CO2

[22] **ESTIMATION OF CHANGES IN SOIL CARBON DUE TO CHANGED LAND USE**
National Carbon Accounting System Technical Report No. 2 November 1999

The chemical and physical properties of soils also help to determine specific information about how well a soil will perform as a filter of wastes, as a home to organisms, and as pool for carbon. If they follow the same characteristics as other comparable types, NT soils hold three times as much carbon as the atmosphere and over four times as much carbon as the vegetation. With 82% of terrestrial carbon in soil (compared to only 18% in vegetation), soil represents the largest carbon sink over which we have control. Soil is also the world's largest store of terrestrial diversity, with over 95% of life forms being underground (that is, only 5% of biodiversity is above ground).



Sequestering carbon in soils represents a practical, permanent and productive solution to removing excess CO_2 from the atmosphere. By adopting regenerative soil-building practices, it is practical and profitable for grazing enterprises to record a net sequestration of carbon in the order of 25 tonnes of CO_2 per hectare. Given that, of the carbon in the terrestrial biosphere, 82 per cent is in soils[23], i.e. four times the amount of carbon stored in the trees and leaves on the surface, why all the emphasis on trees, rather than soil, as a carbon sink? The answer is that people – including most agronomists and bureaucrats – simply don't understand soil carbon sequestration or the role of the microbial bridge and have therefore overlooked it. Pastoralists need to demonstrate the incredible rates at which carbon can be sequestered in soil by roots in biologically based sustainable grazing systems.

[23] Lal R (2004). Soil carbon sequestration impacts on global climate change and food security. *Science* **304**, 1623–1627.

Effective soil carbon management is a key factor for profitable agribusiness, revitalised catchments and participation in the Carbon Farming Initiative (CFI).

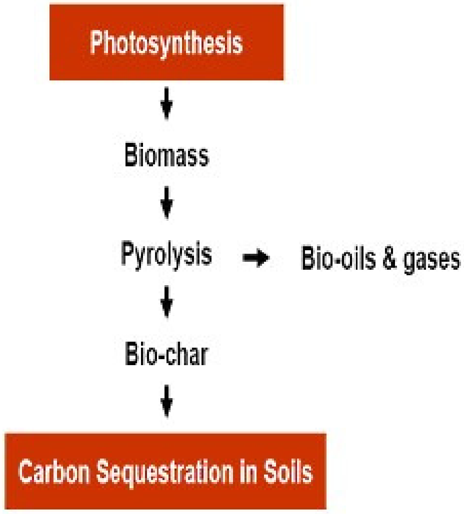
Considerable work has been done by CDU and the Tropical Savannahs CRC in measuring the Soil Organic Carbon at several sites in the Top End. SOC's range from less than .5% at 1 metre up to 4% at the surface, measured at Howard Springs. It is suspected that this data is not widely known, certainly by the people that have framed the EIS guidelines.

By using appropriate carbon sequestering crops that have large root systems, a case could be made that regeneration of savannah, rather than adding to emissions, is in fact producing a carbon sink.

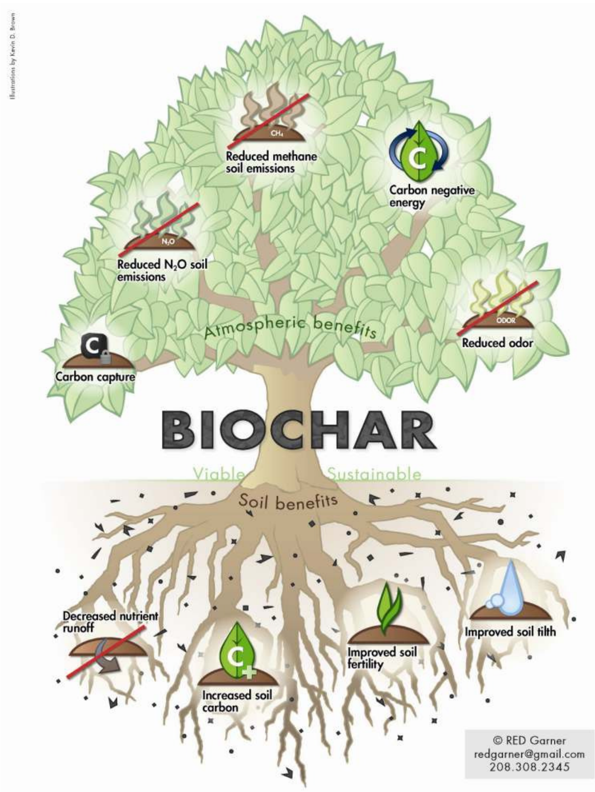
Rather than purchasing offsets for future land clearing it may be possible to create offsets for sale to other Territory business. The case for land 'clearing' per se causing a net increase in emissions cannot be made – it's not 'clearing' land but 'burning' land, either to increase production of edible grass (pastoralists) or in an attempt to manage weeds that causes the problem. If landholders were to stop burning weeds and knocked down trees then re-vegetation of cleared land may very well be carbon negative.

Using Pyrolysis to increase organic carbon in soil.

Biomass (e.g. the waste left after chaining) can be converted to charcoal by slow anaerobic burning – a process termed *pyrolysis*. The biochar can then be dug into the soil, or distributed along with pasture seeds and/or other fertilizer, where it serves a double purpose.



Firstly the carbon is held by the soil for a very long time, and not washed out as was previously assumed. This is the basis of the sequestration aspect of the process of biochar. But the charcoal forms a structure in the soil that encourages life, such as nitrogen-fixing bacteria and other microorganisms. It functions like a soil-based 'coral reef'. In this way, and in others no doubt yet to be researched, the fertility of biochar treated soil is enhanced – sometimes for hundreds if not thousands of years.



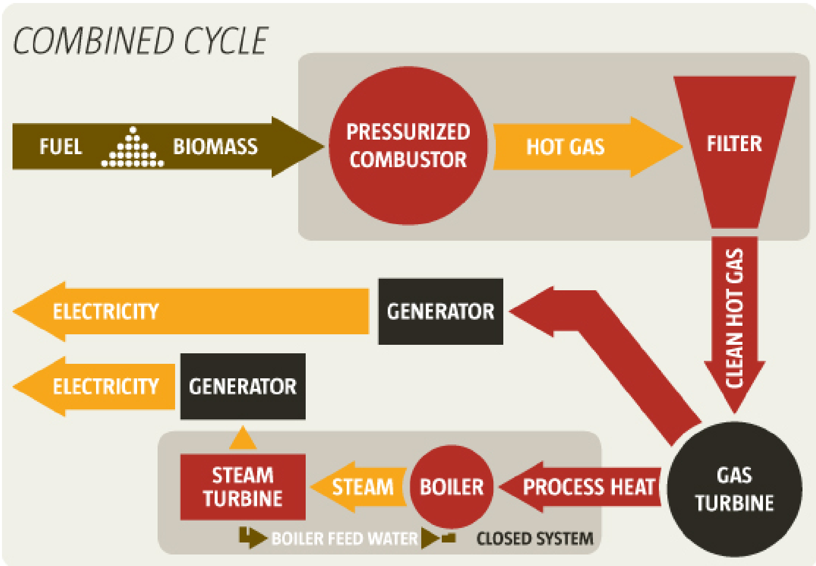
The use of biochar in combating climate change has been promoted by luminaries such as Tim Flannery, James Hansen, NASA's director of the Goddard Institute of Space Studies, and Professor James Lovelock, originator of the Gaia Theory.

It also attracted media attention with announcements from Malcolm Turnbull and the shadow environment minister, Greg Hunt .

Turnbull said: *"We have an enormous opportunity here in Australia to absorb millions of tonnes of carbon dioxide from the atmosphere, store it safely as carbon, and put it back into the soil and increase the productivity and the health of our own landscape."*

ABC video: Agrichar – a solution to Global Warming ?
http://www.abc.net.au/science/broadband/catalyst/asx/Agrichar_hi.asx

Biomass is unique among renewable energy sources. Firstly, it has a complex supply chain (from biomass resource to delivered service), whereas all other renewable sources, like wind or wave energy, have much simpler direct supply chains [sun ➡ collector ➡ generator]. There are many biomass sources including waste wood, specifically grown 'energy crops', and residues from forestry, agriculture and food manufacture. These biomass sources typically go through two stages of conversion: the first to generate a fuel by biological, thermal or chemical means; the second to generate useful energy through, say, a boiler which gives a delivered service (heat, electricity or biofuels for transport). This leads to a large number of possible combinations of sources, conversion processes and technologies and delivered services.



Secondly, unlike wind or wave, biomass has a fuel cost. The prices of biomass fuels are set by market forces and are susceptible to sharp variations due to weather conditions and changes in demand from other industries that draw on biomass sources such as food, furniture and paper. This poses difficult questions for both policy-makers and companies wishing to exploit biomass energy. For example, which of the large numbers of biomass chains are economic? Which generate material carbon savings and other non-financial benefits? Will future fuel price changes alter the relative economic attractiveness of the biomass chains, and will technological developments significantly alter the picture?

To overcome the major barriers to development of a biomass industry a new database on the soils of Northern Australia that improves knowledge of the current and future land productivity as well as the present carbon storage and carbon sequestration potential, is needed. Derived from the soil database, agronomists could produce a Carbon Map that allows for the identification of areas where soil carbon storage is greatest and the potential for sustainable growth of energy crops in degraded soils.

Appendix A.

The emerging carbon economy for northern Australia: challenges and opportunities.

November 2012[24]

Contents.

Executive summary.

The market is an emerging one with the potential of around one billion dollars (and realistically over 100 million dollars readily attainable) if all the potential opportunities are captured and a burgeoning biofuels industry is realised. The benefits that arise from the operation of the carbon economy will not be confined to climate change action but could also generate environmental and livelihood benefits from the operation of this market.

Three strong prospects exist:

- Reduced emissions from fire and livestock that could generate tens of millions of dollars per year if only partially realised;
- Increased biosequestration in soils and vegetations that has been shown if fully realised through improved fire management to be worth in excess of $2M per year on the Tiwi Islands alone.
- Growing feed-stocks for biofuel production is an emerging opportunity that could generate up to 5% of Australia's airline fuel needs.

[24] http://www.regional.gov.au/regional/ona/carbon-economy-for-northern-australia-2012.aspx

