



The
South African
Carbon Sinks
Atlas
2017

synopsis of the online version



environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

First Edition

The
South African
Carbon Sinks
Atlas
2017

synopsis of the online version

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

On behalf of:
 Federal Ministry
for the Environment, Nature Conservation,
Building and Nuclear Safety
of the Federal Republic of Germany

CSIR
our future through science

 **NRF**
National Research
Foundation
SAEON
South African Environmental
Observation Network

NATIONAL CARBON SINKS ATLAS

2017

Acknowledgements

Data layer

LADA and Land Use classes
LADA land degradation index
LADA loss of cover
Dynamic vegetation model 1990
Dynamic vegetation model 2100
Gully erosion
Savanna above ground woody biomass tDM/ha (100m)
Savanna woody fractional cover percentage (1km)
Savanna woody fractional cover percentage (100m)
2013 – 2014 National Land Cover - 72 Classes
Rain 1986 – 2015 median
Rain 1986 – 2015 10th percentile
Rain 1986 – 2015 90th percentile
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1986 and 2015, median and 10th percentile
Temperature (min. and max.) A2 change between 2000 and 2055
10th percentile
Temperature (min. and max.) A2 change between 2000 and 2055
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Rain A2 change between 2000 and 2055 10th percentile
Rain A2 change between 2000 and 2055 90th percentile
Biome shift maps
Alien invasive species

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Source

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The online Carbon Sinks Atlas is available at <http://carbon-atlas.dirisa.org>

Disclaimer

Users need to consider the accuracy and spatial scale of individual products and the way they were derived when attempting to use data for specific locations. Users are also strongly advised against site-specific interpretations based on the national level data, which by its nature is relatively coarse resolution.

Citation

This document should be cited as:

The South African Carbon Sinks Atlas, first edition (2017) Department of Environmental Affairs, Pretoria, South Africa

FOREWORD

The Agriculture, Forestry and Other Land Use (AFOLU) sector is unique in that it is the only sector that contains both sources and sinks for carbon dioxide (CO₂) emissions. Land-use activities, including agriculture, deforestation and rangeland degradation, account for nearly a quarter of global anthropogenic greenhouse gas emissions. On the other hand, forests, grassland and soil systems account the largest proportion of carbon sinks globally. Knowledge of the distribution of carbon sinks and fluxes at a national scale is important to understand their magnitude, geographical spread and management. Such information is critical since it will contribute towards setting rigorous emissions baselines, and assist in developing stringent measurement and verification systems. Furthermore, such information will assist in identifying gaps and needs that when addressed, will improve the accuracy, transparency, completeness, accountability, comparability and consistency of data collection and management, to fully comprehend the greenhouse gas emissions and removals in this sector.

The Carbon Sinks Atlas (CSA) is a web-based data and information tool aimed at providing spatial distribution of carbon stocks and fluxes across South Africa, and it is the first of its kind. In this first edition, the CSA details soil and vegetation's carbon content in the form of carbon data layers (maps) and metadata, based on the National Terrestrial Carbon Sinks Assessment (NTCSA). The intention is to provide access to more accurate national wall-to-wall estimations of carbon stocks and fluxes to a wide range of stakeholders. The CSA is also a contribution to the knowledge management and information initiative which is driven by the Department of Science and Technology (DST) to complement the South African Bio-Energy Atlas and the South African Risk and Vulnerability Atlas (SARVA). Taken together these atlases provide critical information towards addressing the global change challenges facing South Africa.

Although the independent research (conducted by various institutions) contained in this report do not represent the views, opinions and/or position of Government, the department believes that this product is critical to enhance our understanding of the carbon dynamics in the AFOLU sector of South Africa. Hence the department is happy to make this work publicly available and accessible via the SAEON web portal.

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CARBON STOCKS AND FLOWS

The Carbon Sinks Atlas (CSA) was conceived from the National Terrestrial Carbon Sinks Assessment (NTCSA). Its purpose is to present downloadable data and information about the nature of carbon stocks and fluxes at a national level (1 km) for South Africa.

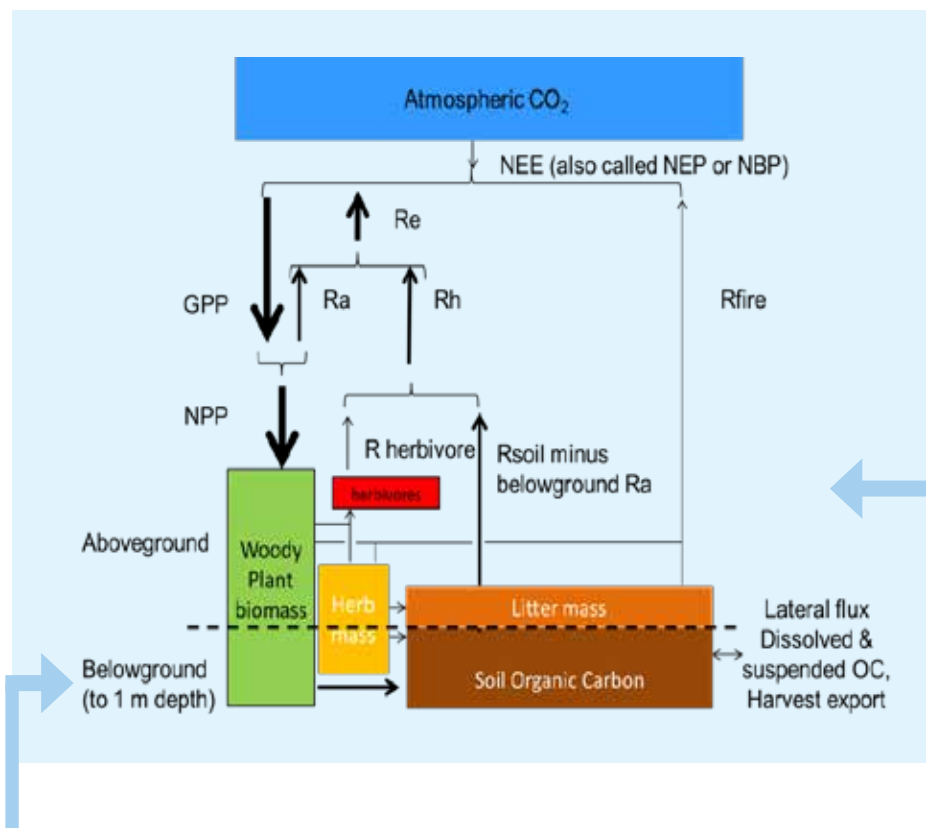
The CSA will provide spatial data in support of responsible land management; support the implementation of policies such as:

The CSA will provide spatial data in support of responsible land management; support the implementation of policies such as:

- National Climate Change Response Policy
- The Carbon Offset scheme and facilitate the improvement of methodologies to account for emissions and removals of greenhouse gases.

Making data & information available

The carbon sinks atlas will make a number of spatially explicit datasets available for viewing and downloading. These have been collected from a wide range of institutions and include information on: above ground, below ground and soil carbon stocks; detailed high resolution savanna tree carbon stocks; net primary production; climatic information; invasive alien plant species; information on land degradation including mapping of erosion gullies; land cover data; as well as future climate predictions and the impacts that they may have on biome distribution. In addition there are supplementary data such as maps of the municipalities which can be overlaid on data for reference purposes. There are also downloadable versions of many key supporting reports, such as 'Assessment of the potential to produce biochar and its application to South African soils as a mitigation measure'.



Components of a generalised terrestrial carbon cycle: The size of the boxes and the arrows, which represent stocks and fluxes respectively, is roughly indicative of their relative size. The herbivore stock is relatively small (<1012 gC nationally), and neither it nor the corresponding herbivore flux was directly evaluated in the NTCSA.

Terminology: NEE – Net Ecosystem Exchange, NEP – Net Ecosystem Productivity, NBP – Net Biome Productivity, GPP – Gross Primary Production, Ra – Autotrophic Respiration (Respiration by plants), Rh – Heterotrophic Respiration (Herbivores, Carnivores and Microbes), Re – Ecosystem Respiration (the combined respiration from all sources), Rfire – fire emissions.

Methodological approach

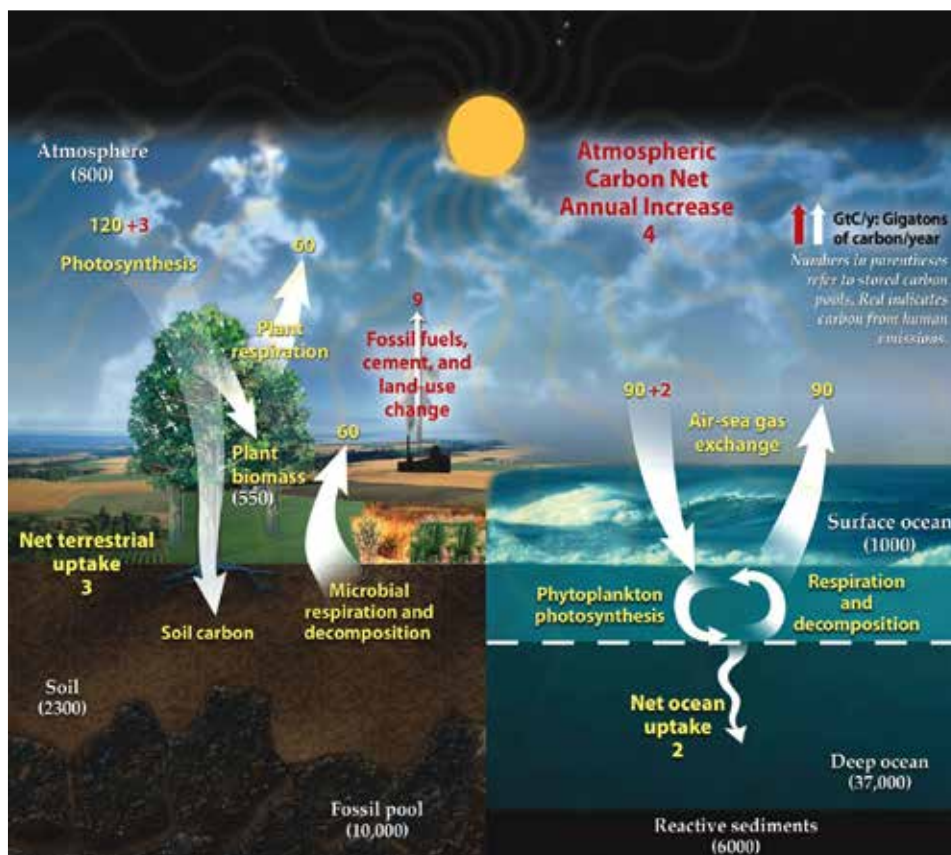
Recent advances in remote sensing and geostatistics were used to estimate above ground woody biomass stocks (i.e. trees and shrubs) across the country, at required levels of accuracy but at low cost. The use of new extrapolation approaches to soil profile data, and models of herbaceous and litter biomass, allowed robust but inexpensive estimates over large areas.

The national carbon stock consists of a set of linked and interacting sub-stocks (called 'pools') which change over time: slowly in the case of soil carbon, moderately quickly in the case of woody biomass, and rapidly in the case of herbaceous and litter carbon. The carbon flows between the pools, and between the land and the atmosphere, land and ocean, and land and human systems are called fluxes.

The full methodological approach to estimate terrestrial carbon stocks and fluxes is described in the NTCSA report which is downloadable from the on-line Carbon Sinks Atlas.



To understand the carbon fluxes in terrestrial ecosystems, the CSIR has installed and maintains three eddy covariance flux towers in Mpumalanga (Skukuza, Kruger National Park; Agincourt, Bushbuckridge) and Limpopo (Malopeni, Phalaborwa)



“This diagram of the fast carbon cycle shows the global movement of carbon between land, atmosphere, and oceans in billions of tons of carbon per year. Yellow numbers are natural fluxes, red are human contributions in billions of tons of carbon per year. White numbers indicate stored carbon.”

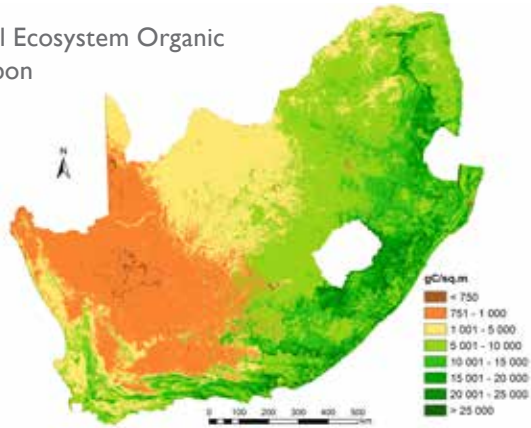
Source: Google. Diagram adapted from U.S. DOE, Biological and Environmental Research Information System. - <http://earthobservatory.nasa.gov/Features/CarbonCycle/>, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=19434238>

THE DISTRIBUTION OF TERRESTRIAL CARBON STOCKS

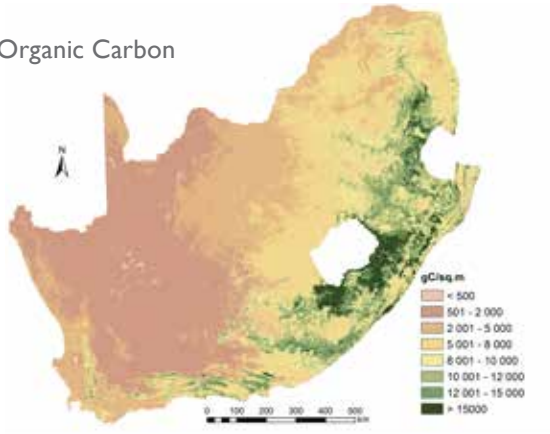
Did you know?

The grassland and savanna biomes contain approximately three quarters of the country's terrestrial carbon stock and account for over 90% of the Gross Primary Production (GPP).

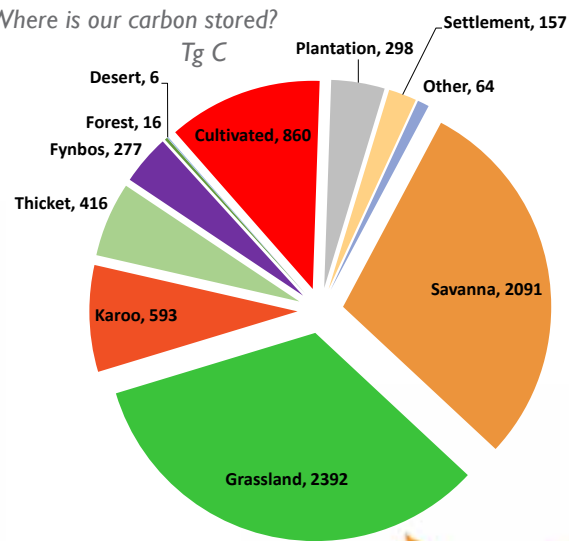
Total Ecosystem Organic Carbon



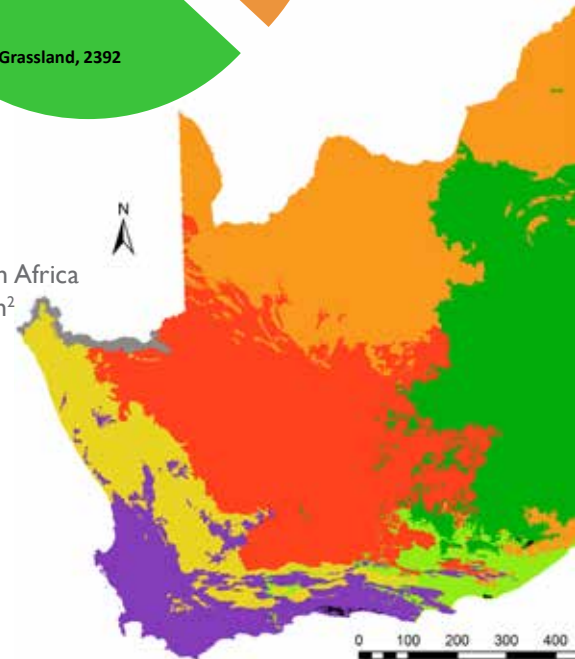
Soil Organic Carbon



Where is our carbon stored?



Total area of South Africa is 1.221 million km²



Introduction

Carbon in the soil is volatile and has the potential to end up in the atmosphere in the next decades if the current trends in land use (e.g. deforestation, land degradation) are not reversed or managed in such a way as to significantly reduce greenhouse gas (GHG) emissions. Amongst the eight mitigation areas identified in the NTCSA, there is a need to implement and scale-up projects in the restoration and management of grasslands, thickets and forests, and improve agricultural practices (principally no tillage or low tillage) in order to curb CO₂ emissions from land.

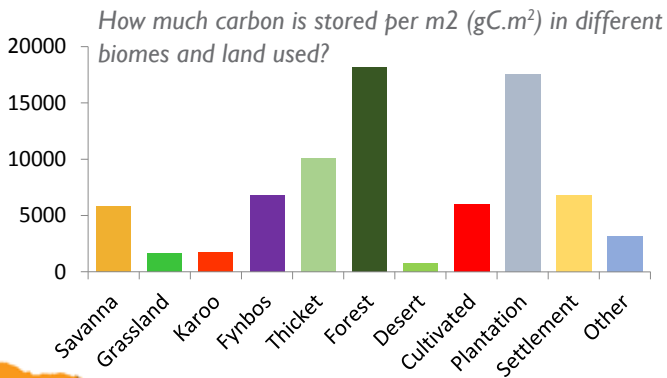
Total Ecosystem Organic Carbon (TEOC)

Terrestrial carbon stocks are determined by plant-available moisture, temperature, soil conditions and vegetation cover. The Total Ecosystem Organic Carbon (TEOC) (units: gC/m²) is the total sum of Soil Organic Carbon (SOC) and Total Biomass Organic Carbon (of natural and transformed areas – crops and plantations). South Africa has a mean TEOC of 6396 gC.m⁻², gross primary production (GPP) of 373 gC.m⁻², and a net primary production (NPP) of 186 gC.m⁻². The online CSA provides data layers and meta data for TEOC and its components at national, provincial and municipal levels.

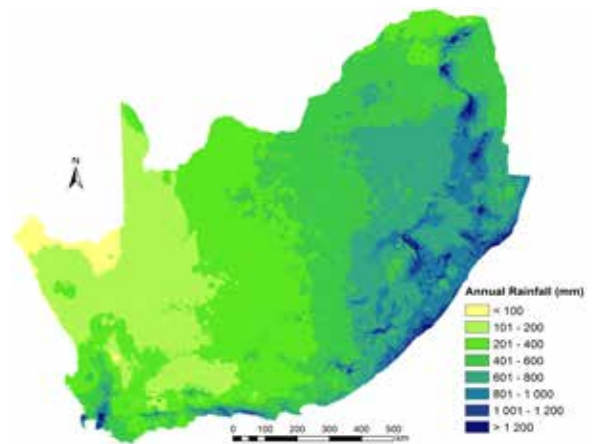
Soil Carbon

Soil carbon is present in two forms: organic and inorganic. Soil Organic Carbon (SOC) is present as soil organic matter (i.e. plant and animal materials in the soil at various stages of decay), and it is the largest part of the ecosystem stock in all South African ecosystems, and the most stable. Terrestrial carbon stocks are higher towards the east coast of South Africa because of higher summer rainfall, carbon dioxide fertilisation, warmer temperatures, fewer large herbivores and regulated fire regimes. In order to balance the land use needs between agriculture and protecting grasslands for an example, we need projects that can identify carbon rich soils (histosols), and introduce farming methods that promote low or no tillage of the soil.

THE DISTRIBUTION OF TERRESTRIAL CARBON STOCKS



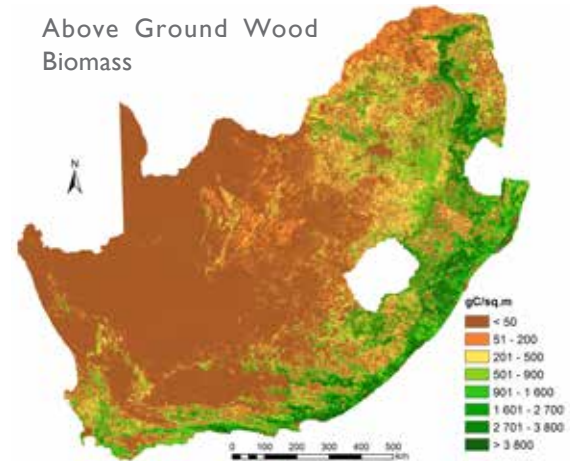
RAINFALL



Did you know?

The bulk of carbon (about 93%) is stored in the soil. Any form of soil disturbance, such as tillage, may lead to loss of soil carbon.

Above Ground Wood Biomass



Biomes and carbon storage

Per hectare, forests sequester the most carbon, however, because of their relatively small size they have an overall small contribution to the country's total carbon stocks. Grassland and savanna, with far less per hectare carbon stocks, contribute the largest proportion of the total carbon store. Thickets, despite their arid nature, have a disproportionally high carbon stock.

Climate and carbon storage

There is a general trend across the sub-continent that links rainfall with both above ground and below ground soil carbon. Grasslands, although having low above ground carbon stocks, compensate by having some of the highest soil carbon stocks. Temperature also plays a role in the accumulation of soil carbon. High temperatures result in rapid soil transpiration which can reduce soil carbon stocks. However this can only take place if there is sufficient moisture. The cool, high altitude grassland areas are especially important for accumulation of soil carbon stocks, hence the need to conserve and preserve them.

Precipitation and Above Ground Woody Biomass

Woody vegetation is more productive across moist soils. South Africa has warmer average temperatures (>17°C), and will likely experience more precipitation towards the eastern escarpment of the country. These conditions, in concert with CO₂ fertilisation, presents opportunities for the restoration of degraded forests (Mpumalanga, KwaZulu-Natal) and thickets (Eastern Cape). Furthermore, land has been identified for small scale afforestation in these provinces that will benefit from climate change.

Impacts of land use on carbon stocks

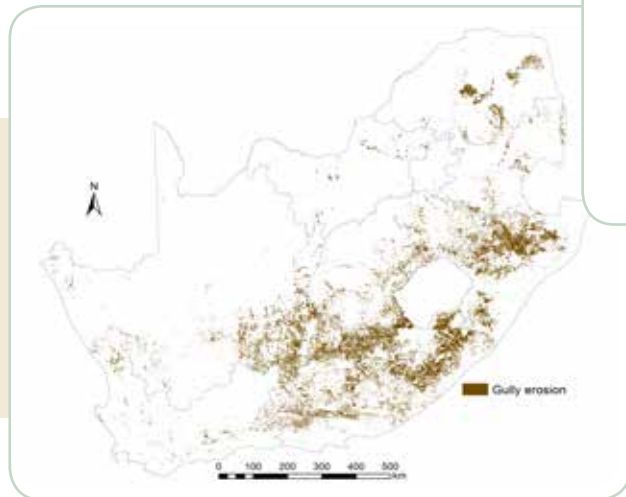
Crop agriculture can reduce soil carbon by 40 – 60 % from what existed in a natural grassland or savanna. Given that in grasslands there can be 100t/ha or more of soil carbon, this can be over 60 tones of carbon which is 220t CO₂ per hectare. Given that about 12 million hectares of land are used for crop agriculture, this represents a substantive emission.

Urban expansion and mining reduces above and below ground carbon. The extent of this impact is unclear, and will differ between areas with well kept gardens versus subsistence dwellings. The current spatial extent of settlements is still a small fraction of total land use, but is growing rapidly.

Degradation reduces above ground and below ground carbon. The thicket biome might lose over 100t/ha of carbon when overgrazed. Loss of indigenous forest would be of the same magnitude. For most other biomes the loss will be less, but still substantive. Most degradation increases soil erosion, and this removes carbon, some of which ends up sequestered in wetland systems. Reduced plant cover over the long term lowers soil carbon.

Gully Erosion Map of South Africa

Not only do gullies result in a loss of soil and soil carbon, but they also reduce agricultural productivity as well as hinder movement of humans and livestock



Anthropogenic impact

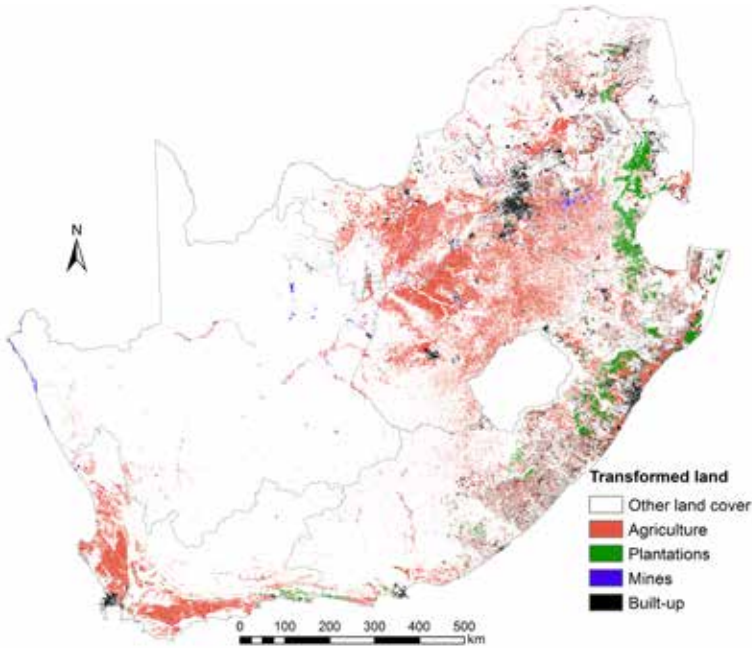
For the first time in the history of the planet Earth, people have managed to keep the global average concentration of CO₂ above 400 ppm - with an annual increase of 2.5 ppm! The burning of fossil fuels, deforestation, soil tillage, and the use of inorganic fertilisers produce greenhouse gases. Locally, over staking and overgrazing, in concert with infrequent sporadic heavy rainfalls, leads to soil erosion and the creation of gullies. Gullies are observed in all provinces, but most notably in the Eastern Cape, KwaZulu-Natal and the Free State. Mining operations often destroy the soil, and poor rehabilitation exercises render the land unsuitable for any form of farming. The Mpumalanga provinces and the Karoos are the most affected provinces.

Potential for land rehabilitation

There is perhaps as much as 10 000 km² area of degraded thicket (spekboom, *Portulacaria afra*) on privately owned farm and communal land potentially available for restoration in the Eastern Cape province. Degraded grasslands and savanna can be rehabilitated through changing grazing and fire regimes. In severe cases gully filling activities may also be appropriate. Conservation agriculture techniques such as no-tillage can reduce losses or even create gains in carbon on cropland.

Alien invasive plant species

South Africa is exceptionally susceptible to invasion of exotic plant species. The fynbos and grassland biomes seem especially susceptible. In many cases these are tree species which accumulate greater above-ground carbon than the vegetation they replace. Although this assists in sequestering carbon, it has even greater costs in terms of lost biodiversity, reduced streamflow, lowered water tables, reduced grazing and the loss of other ecosystem services coming from the indigenous vegetation. Mechanisms need to be found where the carbon from the aliens can be captured during the Working for Water (WfW) and other Extended Public Works Programs.

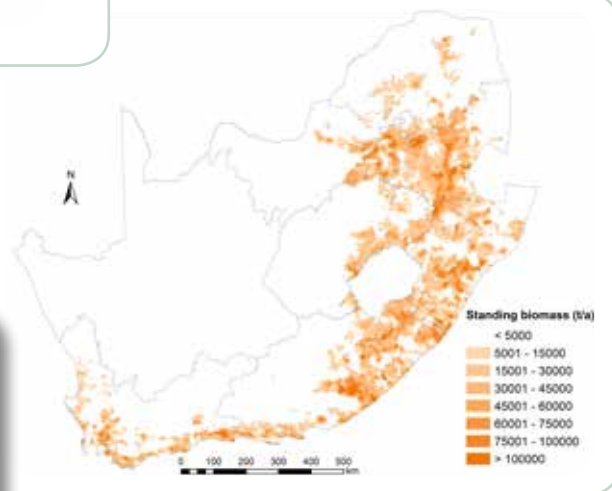


Between 40 and 60% of soil organic carbon is lost during long-term dryland crop agriculture

Alien invasive plants can have mixed long term impacts on carbon sequestration. Although they typically increase aboveground carbon stock, they can also increase fire risks and degradation to the soil. They have very clear negative impacts on biodiversity, and hydrology.

Promoting carbon retention when clearing alien plants

The Extended Public Works Program's WfW initiative has had great success in reducing alien plant invasion. Some of the cleared material, like pine, is used in value-added projects to produce eco-furniture in the Cape Provinces. Other products from alien invasive plant species include biochar. Biochar is produced in the absence of oxygen through a process called pyrolysis, from biomass material. Deploying biochar in soils results in benefits that include enhanced agricultural yield, a reduction in leaching of nutrients, a reduction in soil acidity, increased soil water retention and a reduction in fertilizer use and irrigation requirements. The biochar is relatively inert and can remain in the soil for prolonged periods of time.



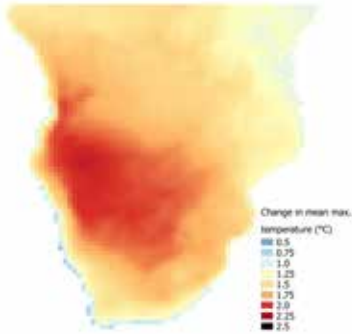
Key messages

- Carbon is lost through both agricultural practices and bad land management;
- There are many opportunities to reduce or reverse carbon loss from the land use sector, such as low or no tillage and adding biochar as a soil supplement;
- Land owners and managers need to include planning around carbon gains and losses when deciding on land use activities. In many cases there can be win-win solutions where increasing carbon can improve other farming practices.
- The society at large must be informed about the effects and impacts of climate change to create an awareness and a sense of responsibility to the environment .

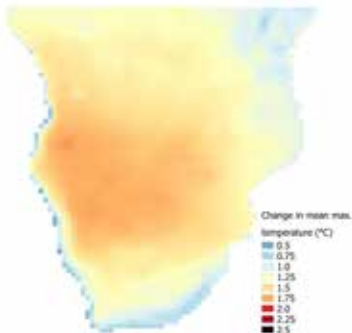
IMPACTS OF GLOBAL DRIVERS ON CARBON STOCKS

A2 mean max temperature

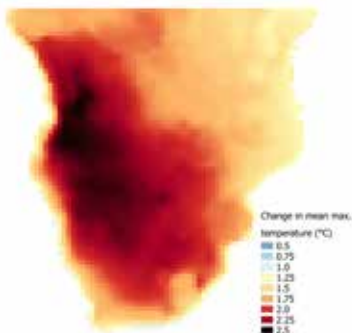
Median



10th Percentile

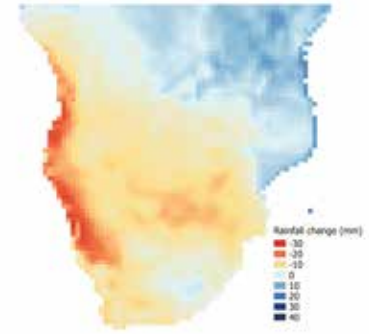


90th Percentile

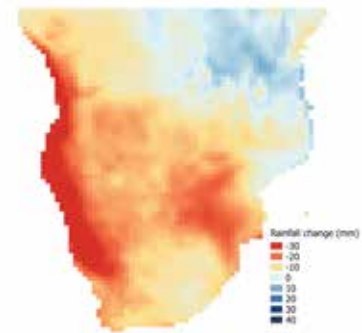


A2 mean annual rainfall

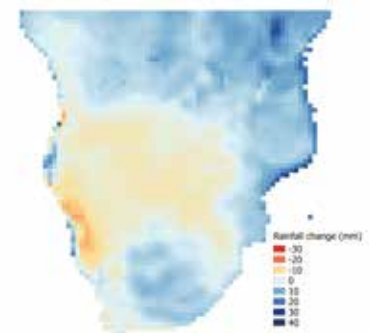
Median



10th Percentile



90th Percentile



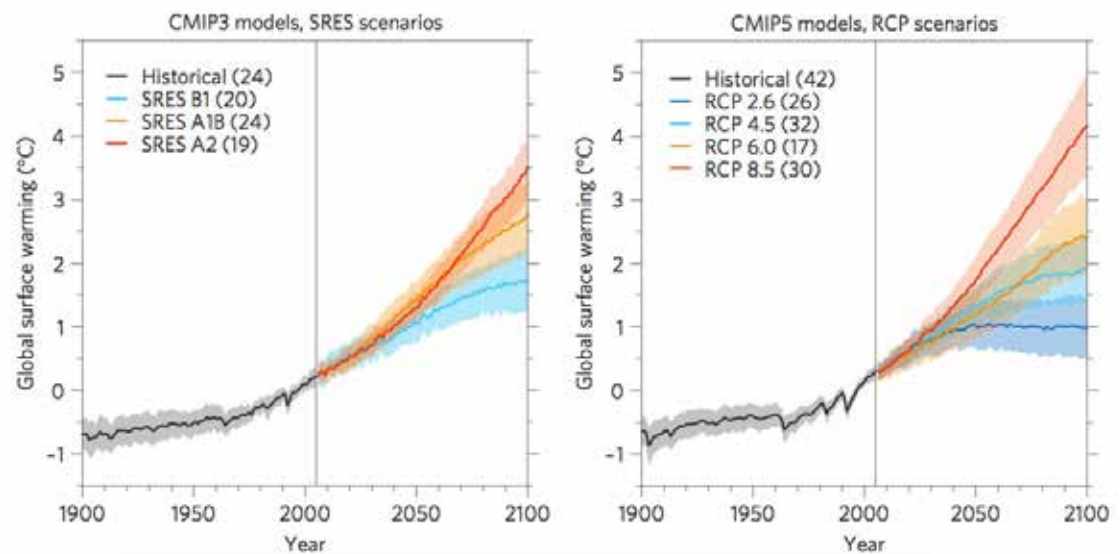
The global climate is changing

How it will change and how this will impact on global carbon stocks is less clear. Within South Africa we are relatively certain that temperature will rise over the next 100 years, and we know this impact will be greatest in the interior, with the coastal areas being moderated by the ocean. The already arid Kalahari area is anticipated to warm at a rate that is close to double the global average. If globally we are able to restrict global warming to just 2°C this region will be, on average, 4°C hotter. Current climate trends confirm these predictions. The future rainfall of the region is far less clear. However, it appears that the already arid western side of the country may become dryer whilst the moister eastern escarpment might in fact become slightly wetter. From the perspectives of plant or crop production an increase in temperature coupled with a decrease in rainfall will result in an overall lowering of net primary production. For rangelands this will therefore mean a lower livestock or game carrying capacity. It will also, over time, reduce both the above ground and soil carbon stocks.

IMPACTS OF GLOBAL DRIVERS ON CARBON STOCKS

The future climate is unknown, but will be largely determined by the degree to which society is able to curb its CO₂ and other greenhouse gas emissions. Complex models aid us in attempting to better predict what the future might look like. The A2 climate scenario above represents possible future climates given ongoing high CO₂ emissions. The results given represent the 10, 50 and 90-percentiles of 6 different global circulation models that have been downscaled for southern Africa. Source CSIR.

Future climate is highly uncertain, in addition to uncertainties in the modelling approach, there is also great uncertainty as to the degree to which the global population will succeed in reducing CO₂ and other greenhouse gas emissions. Preventing further carbon emissions from land cover change, and assisting the land surface to sequester more carbon through sound resource management can help reduce the global CO₂ levels.



Care is needed when interpreting future climate predictions

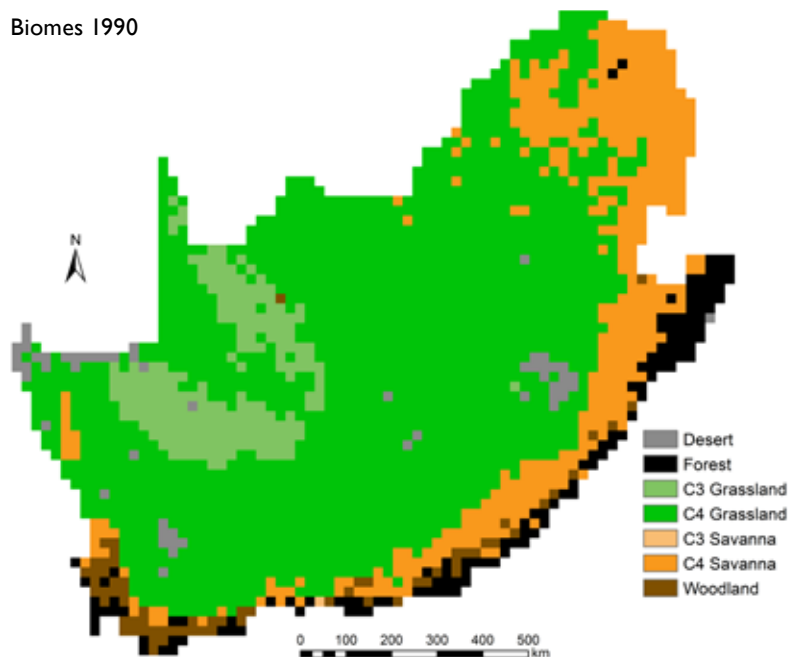
Scientists are getting better at understanding the drivers of the global climate change, but any map of future climate carries uncertainties. We can estimate how much CO₂ and other greenhouse gases will be released into the atmosphere by human activities. Any future assumptions need to be based on a scenario of these future emissions. Furthermore, there are numerous complex feedbacks in the global environmental system. Of great concern is that an environmental threshold may be exceeded that results in un-expected climate impacts. All models are a simplification of the global climate system and are not perfect. Currently a number of Global Circulation Models (GCM) exist (about 30). Each has a bit of randomness and all give different predictions. The common approach is to downscale results of a number of the different models and then to consider the range in outcomes rather than simply the mean result or the result from one specific model. Using data from the median (50% percentile) as well as the 10 and 90th percentile from a range of downscaling's gives a likely range of possible future climate outcomes.

How is rising global atmospheric CO₂ affecting vegetation?

The current global average CO₂ concentration (>400 ppm) is well above the concentrations that persisted when the savanna systems and C3 grasses evolved. C3 grasses and trees however evolved under high CO₂ concentrations and there are signs that species with this photosynthetic pathway may benefit from the raised CO₂ levels. This may have profound impacts on plant species interactions, possibly leading to a greater dominance of C3 plants, and especially trees. It will result in trees being able to take up carbon more easily, and hence increase their carbon storage. Plants may become more woody, and with an increased carbon to nitrogen ration in their tissues. Plants will also become slightly more drought hardy. Increased CO₂ is leading to a global increase in the world's 'greenness'. Though this is good for carbon uptake it carries numerous negative consequences such as lowered palatability to livestock, changed biodiversity, reduced groundwater and bush encroachment.

Dynamic vegetation models (DVMs) are a way to predict future vegetation distributions based on the impacts of global change

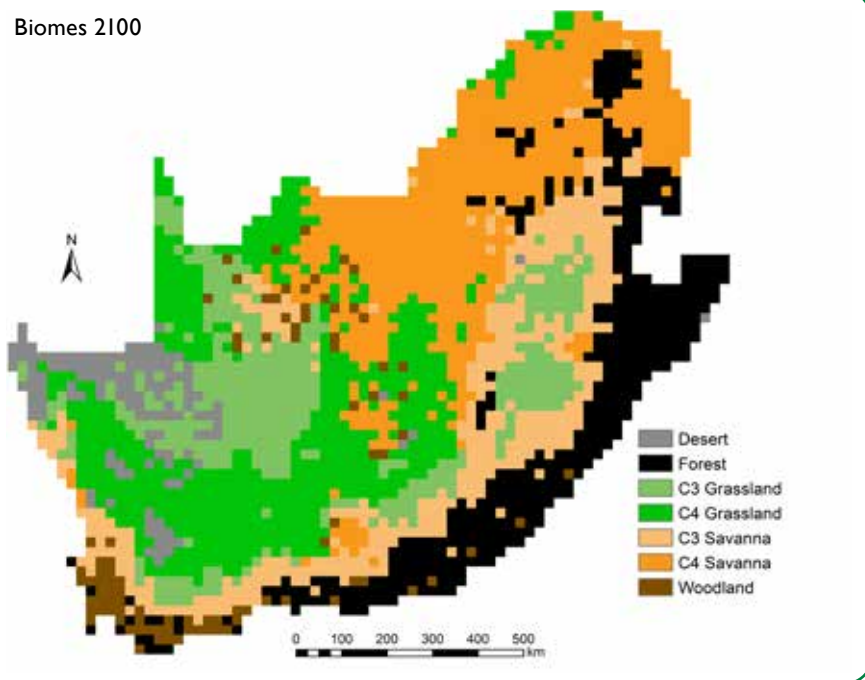
Biomes 1990



They replace simpler niche based biome shift models that fitted biomes simply to a set of climate variables. Currently the models cannot accommodate individual species, so instead they simplify vegetation into a few functional types. These could be based on structural characteristics (such as trees vs grasses) or functional attributes such as between C3 versus C4 photosynthetic pathways. The model is then driven by climatic variables. Regardless of whether niche-based or DVM approaches are taken, the message is clear: biome boundaries are likely to shift as a consequence of climate change. One of the biggest losers is likely to be the grasslands. These are going to be encroached by both the savanna and forest biomes. Evidence of this is already apparent, with many savanna species becoming more prevalent within the grasslands. There is some evidence though that grasslands may migrate slightly into the Nama-Karoo. The succulent karoo is another vegetation type that might be under high pressure. This vegetation type is unique, with many endemic plant species. Its existence is dependent on a habitat which is arid, but with winter rainfall. If its habitat becomes either wetter or the seasonality of rainfall changes then many of the unique plant species will be lost. Savannas are a mixture of C3 trees and largely C4 grasses. Long dry winter periods where the grass dries and supports wild fires are a common feature of savannas, especially in the moisture areas. A prevailing theory is that there is a 'fire trap' that prevents young tree seedlings from developing to a height where they can escape fire. The impact of browsing also prevents the trees from growing. There is growing evidence that the global increase of CO₂ might change this dynamic. C4 grasses and savannas are quite recent and evolved during a period of low global CO₂. C3 trees evolved during a period of higher CO₂ and need to assimilate a lot of CO₂ to build the carbon intensive stems that support the trees. Under low CO₂ environment's trees were forced to grow slowly, However as global CO₂ increases it is thought that trees will be able to grow faster. This has been demonstrated experimentally by growing trees in growth chambers with raised CO₂ (see the photo below). In this experiment it was found that Acacia karoo seedling formed a very small root system when grown at the global CO₂ concentration as found pre the industrial revolution. When grown at current global CO₂ levels the roots were far bigger, and if CO₂ was increased to 450 ppm there was even more root growth. What this concentration of carbohydrates in the roots mean is that now the plant is able to put on a far greater above ground growth within a single growing season, potentially enabling it to grow to sufficient high to escape the 'fire trap'. Similar experiments with grass had less impacts. What this could potentially mean is that savanna areas might become more woody, eventually achieving a closed canopy and largely eliminating grass, and hence further suppressing fire. If this where to happen then what was previously savanna might in the future become a closed canopy forest. The widespread occurrence of bush encroachment throughout the savanna region might, in part, be due to this CO₂ impact. Some DVMs have suggested that there might be a wide spread movement from savanna to forest over Africa including in the moister areas of South Africa. However, any functional DVM must take into account the ecophysiology of all vegetation types in South Africa.

IMPACTS OF GLOBAL DRIVERS ON CARBON STOCKS

Biomes 2100



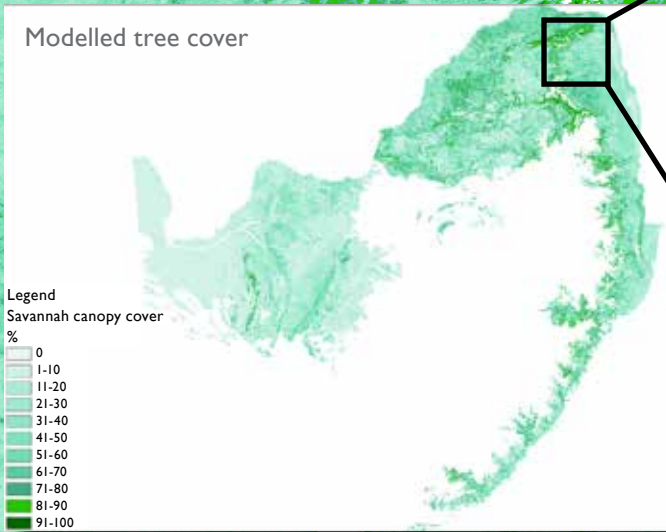
Some trees appear to respond positively to increased global CO₂ concentrations. These Acacia karoo seedlings were grown in chambers with varying concentrations of CO₂ to represent past, current and possible future CO₂ concentrations [Picture Courtesy of Barney Kgope, following a CO₂ gradient experiment at Kirtsenbosch, NB: Present CO₂ is >400 ppm]



Bush encroachment like alien invasive plants, may well result in increased terrestrial carbon stocks

Increasing above ground carbon stocks may be obvious, but the below ground impacts are less well understood. Though bush encroachment may be good for carbon sequestration, it would be at the cost of many other land benefits. For instance bush encroachment can reduce the cattle carrying capacity of rangelands by 5 to 10 fold. For wildlife farmers it has many negative impacts, in addition to reducing grazing capacity and excluding plains animals from the reserve, it also makes viewing of game extremely difficult, reducing wildlife experiences. It substantially changes both plant and animal biodiversity and water resources may also be negatively impacted. Like for alien invasive plants, there are a number of mechanisms where bush encroachment can be controlled whilst still maintaining the carbon sequestration. This could involve using the biomass to offset fossil fuel in energy generation, or the use of biochar as a soil enhancement.

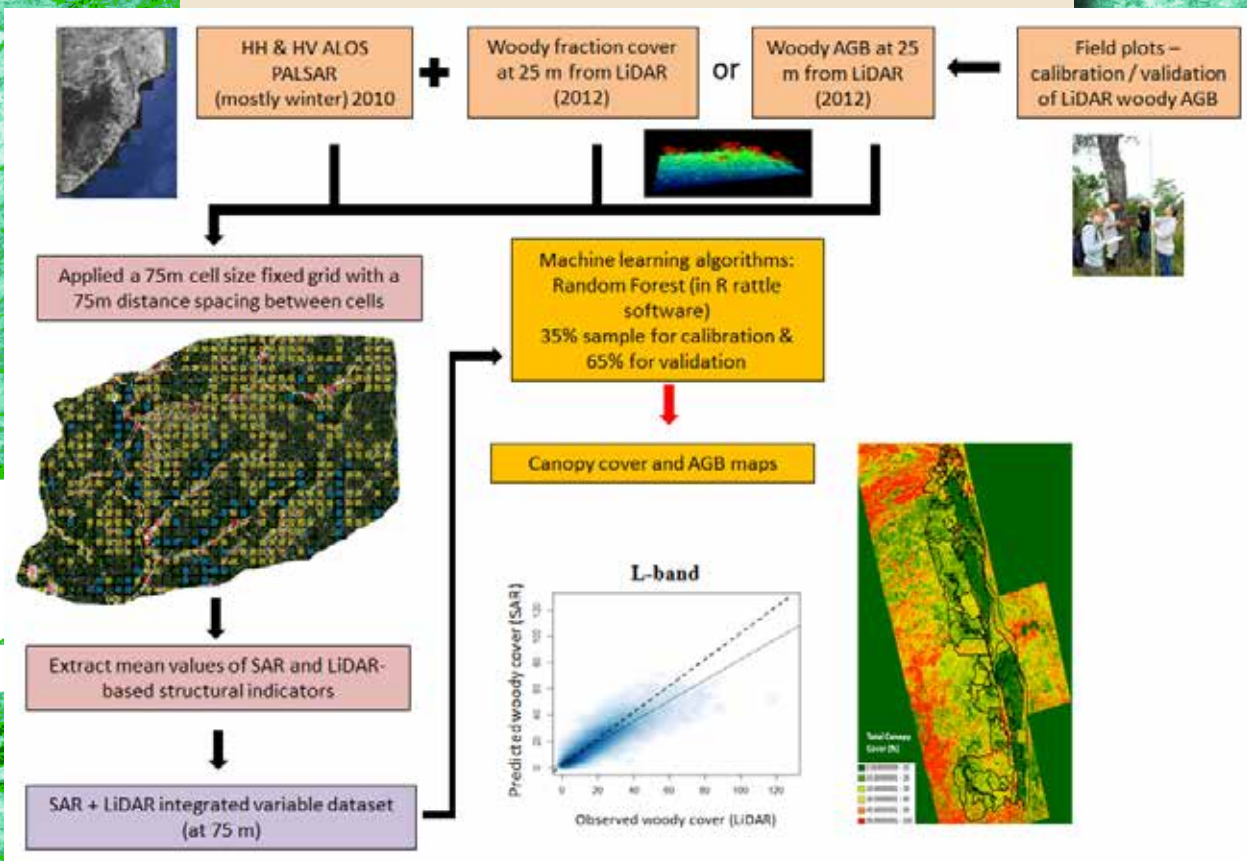
LOWVELD SAVANNA TREE COVER



100m resolution woody biomass for the savanna regions

The savannas are probably the most important carbon stock in South Africa, and certainly when considering southern Africa. Although the per hectare carbon is substantively lower than in forests, it is the vast areas involved that mean that the savannas are south Africa single biggest carbon store. Reduction of tree cover in the savanna can greatly reduce this store of carbon, especially if soil carbon is also lost, as will be the case on degraded or transformed land. The savanna a carbon stock can be manipulated through management actions such as fire and grazing regimes.

The NTCSA used the IPCC's Tier 2 approach, as Tier 1 provided locally inaccurate assessment of standing tree biomass. This has been updated to a high resolution estimate of above ground woody biomass based on improved assessment methodologies and extensive ground verification. This methodology is summarized in the image below. This methodology has allowed the development of a 100 m resolution tree biomass cover for the savanna regions of South Africa. Other biomes have not been included as the methodology has not been calibrated or verified for them. For the same reason, plantation forestry and riverine vegetation has been excluded.



LOWVELD SAVANNA TREE COVER

A fence-line contrast between Kruger National Park and the none-conserved areas around it shows a clear difference between woody cover within and outside of the park, with the park having a far lower woody vegetation density. This is most probably a result of the high elephant density within the park.

Clear impacts of geology on tree biomass can be seen in the Kruger National Park where the areas to the east on the basalt have a very low tree biomass compared to the granite areas more to the west. The Libombo mountains on the border with Mozambique which are on Ryolite also have, in comparison, a higher tree biomass.

Firewood remains the main source of cooking fuel in most rural villages, this despite electrification. It is common to find areas cleared of trees in a circular patten around the village, with villagers having to travel increasingly longer distances in order to access firewood.

Bush encroachment has had a dramatic impact over large areas of the savanna. It can make the area almost impenetrable to humans, greatly reducing the value of the area for both livestock and wildlife. Fire, coupled with heavy browsing, is a traditional way of managing bush, but when bush becomes thick there may be too little grass to support a hot fire. From a carbon perspective bush encroachment may increase above ground biomass, so clearing it in effect emits carbon. However, if the bush were used to offset fossil fuel use, or the bush were to be converted into biochar then in effect its use could be seen as reducing global greenhouse gas emissions.



LAND BASED CLIMATE CHANGE MITIGATION OPPORTUNITIES

The National Terrestrial Carbon Sink Assessment published in 2015, identified eight land based mitigation opportunities. These are mentioned in the table below and are well described in the original report (www.environment.gov.za/documents/research). Implementing these measures presents the opportunity to address degradation and institute sustainable management regimes. The benefits include inter alia enhancement of carbon stocks, the reduction of greenhouse gas emissions, significant reduction of dam siltation downstream, topsoil retention. More importantly by rehabilitating these systems the ecological infrastructure is enhanced.

Activity	Sub-class	Spatial extent (ha)	Reduction in emissions over 20 yr (tCO ₂ e) (min)
Restoration of sub-tropical thicket, forests and woodlands	Sub-tropical thicket	500 000	44 000 000
	Coastal and scarp forests	8 570	1 131 240
	Broadleaf woodleaf	300 000	24 200 000
Restoration and management of grasslands	Restoration – Erosion Mesic	270 000	13 860 000
	Restoration – Erosion Dry	320 000	11 733 333
	Restoration – Grasslands Mesic	600 000	22 000 000
	Avoided degradation mesic	15 000	1 100 000
Commercial small-grower afforestation	Eastern Cape	60 000	2 750 000
	KwaZulu-Natal	40 000	1 833 333
Biomass energy (IAPs & bush encroachment)	Country-wide		39 806 316
Biomass energy (bagasse)	Country-wide		6 579 099
Anaerobic biogas digesters	Country-wide		72 848 160
Biochar*****	Country-wide	700 000	12 833 333
Reduced tillage****	Country-wide	2 878 960	21 112 373
Reducing deforestation and degradation	Through planning		
	Through regulation		
Total			275 787 189

The rehabilitation and sustainable management of these systems enhances both the ecological infrastructure and its function. This in turn delivers ecosystem goods and services that inter alia include water provision, improved soil health, carbon and nutrient cycling.

TAKE HOME MESSAGES

- Globally, atmospheric carbon dioxide is increasing at an annual rate of 2.5 ppm, and there is a high level of consensus that this is a direct cause of climate change. We urgently need to globally reduce carbon dioxide and other greenhouse gas emissions, and increase the level of carbon sequestration. Failure to do this will result in extreme climate consequences with much of South Africa expected to experience devastating impacts. Reducing emissions needs to be a global commitment, with each country doing its part. South Africa has made global commitments at several UNFCCC COP conventions in this regard.
- Globally and nationally, mechanisms will be introduced to support, facilitate and enforce emission reductions. Some of these will be financial incentives such as carbon payments and Reduced Emissions from Deforestation and Degradation (REDD), or through disincentives such as carbon taxes.
- The terrestrial environment can be both a source and sink of carbon. Managing the environment to increase carbon uptake can be both an adaptation and mitigation strategy. Increasing soil carbon both helps buffer against climate change impacts as well as helps reduce global CO₂ levels.
- Prevention of land transformation, especially from mature vegetation to annual crop agriculture is a first priority in reducing emissions, since huge amounts of soil carbon are lost from dryland agricultural practices. This is especially true for grasslands where most of the carbon is stored as soil carbon.
- Where new fields have to be established, carbon friendly practices such as no-tillage agriculture can greatly reduce the soil carbon loss. Changing to organic farming or no-till practices can help build up carbon in already depleted soils, though this process is slow.
- The savanna and grassland systems are South Africa's biggest terrestrial carbon pools. The soil carbon tends to be more than the above ground carbon, but in savannas, tree biomass can also be a substantive contributor to the carbon stocks.
- Degrading the above ground carbon stocks (either trees or grass) will, over time, also reduce soil carbon stocks. Maintaining or increasing above ground carbon will increase the overall carbon stocks.
- The thicket biome in particular has massive carbon loss through degradation, with high potential for sequestration through restoration. There is the additional benefit of increased biodiversity and improved habitat for wildlife or livestock.
- Alien invasive plants and bush encroachment both increase above ground carbon stocks, but this is at a cost to many other ecosystem services. There are, however, potential win-win solutions where aliens and bush can be cleared without an overall carbon emission. This can be through offsetting fossil fuel use, or through the creation of biochar which can be used to amend agricultural soils.
- Climate change will have profound impacts on current vegetation, including species loss and changing the nature of biome distributions.
- Land use and land use change involves complex trade-offs, with carbon being only one of them. A holistic approach is needed where the contribution of carbon is recognised.

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Publishing date: April 2017

www.environment.gov.za