The BBS Initiative on Biome Boundary / Vegetation Shifts

Meeting Report: Workshop, 27 – 29 March 2011

Maison Cambodge, Cite Universitaire, Paris, France

Table of contents:

Introduction

The workshop was funded by the French Foundation for Biodiversity Research (FRB), GIS Climat and DIVERSITAS. The meeting was organised by Paul Leadley, Heike Lischke, Hisashi Sato and George Hurtt.

BBS objectives

The biome boundary shift (BBS) initiative is mainly concerned with the improvement of dynamic global vegetation models (DGVMs) through the inclusion of biodiversity via the use of plant traits, and incorporation of ecological processes, such as migration and response to disturbance. Further aims are the benchmarking of global and regional vegetation models, and linking global change impacts on biodiversity and ecosystem services at regional and global scales.

There has been a fundamental change in the perception of the importance of biodiversity and ecosystem function, with biodiversity and bio-geochemical studies and assessments now focusing on the levels of traits / functional types and habitat / vegetation type rather than on species as the key to understanding global change impacts.

The first meeting of the BBS initiative took place in Yokohama, Japan, in 2008. Aim of this meeting was to provide a forum to discuss and develop improved methods for predicting future dynamics of vegetation patterns at large spatial scales under climate and land use change, especially at biome boundaries. The second workshop, in Cape Town, South Africa, 2009, was held in conjunction with the TRY initiative, and focused on improving regional and global models of vegetation dynamics and ecosystem function through the incorporation of plant trait data.

Aims of this workshop were to further the improvement of DGVMs, especially the development of new trait-based modelling approaches, integration of migration algorithms and development of new functions for disturbance (fire and herbivory), and to investigate the importance of vegetation shifts under global change. To advance the fundamental science behind the BBS objectives, two projects were introduced – one on migration, the other on fire, and developed further as collaborative projects.

Introduction (Paul Leadley)

The recent modelling synthesis for the GBO3 technical report provides the background for the projects developed during the workshop, as well as for the BBS initiative in general.

Global Change will potentially have large impacts on species extinctions, changes in species abundance, habitat loss, *shifts in the distribution of species, species groups and biomes*, links between biodiversity and ecosystem services, and *tipping points*. In contrast to previous assessments, which were done using single models, the GBO3 use an intermodel-comparison approach, provides a stronger scientific bases, but also increases uncertainty considerably. The most important findings include expected shifts in the distribution of species, species and biomes, and occurrence of tipping points. The report also provides a detailed analysis of tipping points, their mechanisms, impacts, understanding, certainty in projections, and necessary actions for mitigation. The term “tipping point” is used here in a very broad sense, thought to mean changes on a very large scale, leading to considerable, irreversible change. ”

Amazonian Forest tipping point: local and global drivers interact. Climate, deforestation and fire result in forest dieback, which leads to further drying. Preservation of forest win-win situation for biodiversity and ecosystem services (e.g. species conservation and carbon sequestration). A very important fire feed back has been identified in the Amazon – the forest dry out impacts on the local fire regime.

Miombo Woodlands tipping points: the MEA predicts large to extreme destruction of Miombo woodlands. Conversion of woodlands is driven by socio-economic tipping points, coupled with an ecological tipping point that is driven by fire, grazing and rising CO2. Positive feed backs exist that maintain alternate states.

Arctic Tundra tipping point: Coupled albedo / green house gas impacts lead to an increase in boreal forest species, which in turn lead to positive climate feed backs, maintaining boreal forests. In a worst case scenarios, permafrost is melting, but boreal forest can not establish.

Are tipping points "Red Herrings"? A part of the scientific community is sceptical of tipping points, while others are convinced that they exist, and will lead to considerable changes in ecosystems and local environmental conditions. Most models agree that there will be large-scale changes in vegetation cover over the next century. As most models include climate change, predictions of vegetation shifts are to be expected as a consequence. To determine whether tipping points are really irreversible, detailed investigation of interactions of climate change, biodiversity and soil chemistry are required. If climate change is excluded, real tipping points should be identified. Nevertheless, tipping points are important from a policy view, as it needs to be identified what needs to be done to stop what is happening within the next decades. Tipping points are used in this context to highlight large-scale changes that need to be addressed from a policy / decision-making side.

The boreal forest dieback (and subsequent invasion of temperate forest) might also be a tipping point of interested. An increase insect pests, heat and drought stress (due to reduced water availability in summer), coupled with increased small-scale fires and limited seedling establishment (due to increased heat and drought stress), as well as, in some areas, flooding (as water cannot drain) leads to fragmentation of the boreal forest. However, it is not clear whether the temperate forest is able to colonise the open patches that are being created.

BBS migration project (Heike Lischke, Hisashi Sato, Takashi Kohyama)

The MigMIP (migration modelling intercomparison) project is aimed at investigating migration in detail – are the actually able to get to the places where they are supposed to be in the future?

A number of challenges need to be overcome when implementing explicit BBS into DGVMs:

Challenges	**Solutions**
large computing times	parallelisation, efficient implementation, model-upscaling
discretisation errors, within-cell heterogeneity	intelligent spatial upscaling: stratification, adaptive grids, metamodelling, particle methods, moment approaches, multi-scale approaches
PFTs taking dispersal into account	new PFT groupings
Knowledge and assessment of importance of processes	
Parametrisation	
testing	

The ideas for this project were first discussed at the workshop in Yokohama. However, since then, more models with dispersal are available, mechanisms of processes (dispersal, establishment, etc) are better implemented in the models, better computer power is available, new concepts for migration modelling have been developed, and some migration modelling studies are underway.

The goals of MigMIP include:

Short term	**Mid term**	**Strategic**
Critical model parts/processes	Assess future biome shifts	Contribute to IPCC5
Sensitivities	Assess lages due to slow biome shifts	Produce papers
Improve models	Assess role of fragmentation in plant migration/biome shifts	
Tipping points	Data model comparisons	

Potential research questions covered could include:

- what are the state of the art problems and solutions in migration modelling
- how sensitive are simulated biome boundary shifts to model approaches and included processes, particularly regarding dispersal
- *what do DGVMs say what are potential changes on a large scale*
- *what do regional models say about details?*
- how well do models represent observed migrations
- how fast and how do biomes shift in future?
- Do biomes shifts show tipping behaviour?

How can this be achieved?

a) In meetings – bring together vegetation modellers dealing with biome shifts, discuss problems and solutions, set up protocols, compare results
b) at home – prepare input data, run models, compare output data

Suggested way forward

1. Review Paper (building on draft developed in Yokohama)
2. Model intercomparison
3. Model-data comparisons
4. Assessment of future boundary shifts
5. Summary Paper focussing on problems and approaches, prepared for IPCC5
6. Model intercomparison identifying sensitivity to relevant processes, prepared for IPCC5
7. model-data comparison and systematic simulations for assessment of future boundary shifts

Potential Workflow

Step 0: Summary Paper (Cornelia)

Step 1: Model-model intercomparison

This could either be a simple synthesis, which does not requires very stringent / rigid work, or running models for same region, which same drivers, or full-blown model comparison with same climate scenarios and same drivers. It needs to be separated which is scientifically most interesting, and what best serves IPCC? It might be useful to split the work into shorter and longer term projects that not only feed into IPCC, but also result in interesting papers and contribute to IPBES. Dispersal and extinction scenarios, and abiotic vs biotic processes could be considered in long-term projects.

Step 2: Model-data comparison

This represents the “real work” behind the project, and will depend on who can provide what type of data (climate scenarios, land use information, soil data), and needs and wants of modelling groups. Models involved range from landscape to global scale, with some integrating migration. The models working on different grains (fine to coarse), and models running on large scales need to be adapted to run on fine scales. Models could be applied to global, continental transects, or regional transects, or landscape scales.

Way forward

- Thorough sensitivity analysis and meta model analysis
- Identifying probabilities of change and conditions under which changes are happening
- Identification of mechanisms and conditions for change

- Estimation of migration speeds (on species or PFT basis)
- Estimation of uncertainty associated with model outputs

BBS fire project (Dominique Bachelet, Doug Morton)

Large, uncontrolled wildfires have increased globally. Over the next 100 years, climate change is projected to even further increase wildfires (both frequency and intensity). Aim of the project would be to compare existing fire models against the best information available to date.

Proposed activities

- Compile and generate climate and soil data sets
- Gather 20th century fire history - fire variables - geographic domain – fire-related traits (tolerance, intolerance, resistance)
- Compare results of global fire models and state-of-the-art earth system models that include (or will include) fire routines
- Quantify model accuracy and uncertainty at different spatial scales (coarse/fine) and comparing model output with results from landscape fire models at the finer scale
- Identify model improvements (e.g. fire PFTs) to include the best understanding of the interactions between climate, vegetation, and fire
- Run future scenarios with AR4 and the new AR5 scenarios when they are available using both stat. downscaled GCM and RCM results.

Activities Phase 1

- Standard formatting/documentation of climate and soil dataset for model inputs;
- Formatting/documentation of available fire occurrence/impact datasets for model testing;
- Storage of all input and testing datasets in data repository for easy access by group participants;
- Identify protocol for model initialization and spinup;
- Write complete documentation of fire models participating with list of assumptions and description of initial conditions and run protocols.
- Identify output variables to be used for model comparison (ILAMB): carbon stocks, vegetation type, fire impacts, feedbacks

Activities Phase 2

- QA/QC model output provided by teams and format for comparison with observations (centralize model results, verify protocol agreement)
- Formalize comparison between model and observation results
- Define new PFTS reflecting functional diversity with respect to response to fire (e.g. bark thickness, tolerance to high temperatures, resprouting/seedling emergence capacity after fire, tolerance to frequent fires …)
- Integrate in models and rerun
- Sensitivity analysis and disturbance response

Potential outputs

- Paper on changes in fire occurrence and causes (cf. Allen et al., 2010); includedatabase with geospatial info on area burned and timing

- use on line geospatial data base for comparisons, overlay, data sharing and manipulation (e.g. Data Basin – http://databasin.org/)
- workshops
- fire "wizard" - future fire models

Work should focus on selected hypotheses, e.g. investigating the role of fire in shifting biomes (and creating tipping points). Incorporation of PFTs into fire models will be long-term work. A short-term approach could be a paper identifying where fires have been changing (and why), and then link this to the migration project. This also allows for the comparison of models. There might be opportunities to link the migration and fire models. A large number of models have fire integrated – willing collaborators and regions to be covered need to be identified.

Activities in the first phase could be to simply identify the current trends in selected regions (are fires increasing or decreasing?), which models show these, and investigate the reasons behind these changes (climate, land use). Potential regions considered could be the Amazon (this already receives considerable attention), NW US, African Savanna.

Focus of the project can be broadened to focus on aspects that have not been studied previously, e.g. the interactions of REDD, carbon sequestration and fire.

Harmonised land use scenarios (George Hurtt)

Land use has transformed the earth's surface considerably, and affects carbon balance, climate and biodiversity. Thus, future land use decisions are important, as they can contribute to regional or global climate change.

The land use harmonisation integrates reconstructed land use history (1500 – 2005) and the combined integrated assessment models (IAM) and representative concentration pathways (RCP) (2005 – 2100) into gridded land use / land cover scenarios for 1500 – 2100.

Harmonisation steps include the development of a consensus land use history reconstruction, which minimises differences between end of historical reconstruction and beginning of future projections, and preservation of as much information from IAMs on future as possible.

Conclusions

Land use is essential for food, fibre and fuel, but at the same time, it impacts bio-geochemical cycles, biodiversity and climate. To be able to accurately model the effect of land use on the earth system, consistent treatment of past, present and future land use is essential. The new approach to harmonising land use transition across multiple models, model types and scenarios is promising, but further studies are necessary to reduce the remaining inconsistencies, address additional aspects of the role of land use / management and to prepare for the next generation of fully integrated models.

A few issues are still suspect in the current land use harmonisation, as all products should converge once satellite data appear (from 1970s) onwards, which is not the case. The main difference in model outputs thus stem from land use history, and amount of secondary land. Spikes in land use conversion observed, which could be due to the expansion of productive land in the 1950s/1960s, but at the same time, there was also a switch between data sources

For more information on the new products, availability and processing, see http://www.iiasa.ac.at

or http://luh.unh.edu.

NB: the project is a land **use** product, not a land **cover** product, the models are computing the consequences of land use. Savannas not explicitly represented – natural vegetation categories include forest or non-forest. Loss of forest is due to agricultural land expansion close to production areas.

Thoughts and suggestions for BBS projects

The projects developed by the BBS initiative should be relatively rapid synthetic studies of high impact, and IPCC-AR5 relevance. They should also be state-of-the-art model development initiatives that qualitatively advance the dynamical understanding and future projections of the earth system.

BBS/TRY Potential Questions

- How has fire activity changed in the last 500 years, and what are the possible changes in the next 100 years?
    - What are the role of climate

and human

activity/land-use (fire ignitions, suppression, feedbacks, etc.?)

- How much migration has occurred in the last 500 years, and what are the possible changes in the next 100 years?
    - What are the roles of climate and human activity/land use (moving species, species introductions, barriers, etc.)?

Remote Sensing Data for BBS Model-Data Studies (Doug Morton)

Summary of data availability / data products

- Migration
    - continental scale
        - MODIS NDVI trends (Aqua vs Terra Satellite)
            - Terra data has been shown to have a negative bias in long trend times series analysis, leading to negative trends
            - NDVI trends from Aqua show diebacks in boreal forest that have never been shown
    - regional scale
        - Quebec Forest-Tundra BB: Landsat Time Series Transect (1986-2010)
    - climate data validation
        - LandSat TM 1982 – 2010
        - NDVI trends show how do specific plant functional types are responding to climate change
        - time span sufficient to show response in slow-growing boreal forest/tundra
        - able to identify very localised/regionalised phenomenon (e.g. shrubland greening)
- Fire
    - GFEDv3: burned area and emissions update
        - Burned area: 250m – 0.5 deg
        - Ignitions
        - Fire characteristics: fire return interval, fire duration, fire spread, etc.
        - Fire-Climate relationships
    - GFEDv4: planned improvements
        - Higher resolution, spatial & temporal
        - Post-fire recovery (Albedo, LST, NDVI)
            - Fire Severity
            - Combustion completeness

        - “Missing” fire types
            - Understory forest fires in Amazonia, Africa
            - Agricultural fires
        - Fire spread rate, FRI
    - Amazon: ignitions, burned area
        - Time and frequency of fires
        - coupling with climate events (El Nino) – correspondence between fire and humidity
        - interannual variability

Future goal: can we couple DGVMs with radiative transfer models to generate synthetic remote sensing outputs from model runs?

Is it really possible to distinguish shrubs from trees with this type of remotely sensed information? Adequate collection of ground data is necessary to distinguish between the two groups (either through phenology / growth structure) by capturing form and spectral emissions. The results are likely to be consistent, but open for discussion/critique.

Currently rather limited data availability for boreal forest, especially in Siberia. Need to identify a region where there is meaningful data to do these analysis. Potentially Landsat data up to 1972.

Capability to differentiate between crown and ground fire in GFEDv4. Current available fire data needs to be married to climate data to determine effects. Surface vs. crown fires are easier to work with than fire fraction. Corresponding data should be available within a year.

Spatially explicit fire return interval calculations possible. Available burned area data is as consistent as it can currently been made. Availability of individual fire data is a good reason to move into MODIS data.

Peak NDVI is a starting point, determination of growing season is so far limited by WHAR. There is value in this for BBS, but not much can be learned from the data about phenology. It is, however, a way to further refine understanding how ecosystem are functioning in perspective to growing season. MODIS might be suitable to monitor phenology, but there is greater interest in inter-annual than intra-annual changes.

Breakout group reports

Migration - MigMIP

Research Questions

- Effects of migration and its uncertainties on biome shifts
    - uncertainties with respect to
        - formulation of dispersal
        - effect of PFT grouping vs species
        - fragmentation – via land use scenarios
        - general approaches (biogeochemistry, vegetation structure)
        - (feed backs)
    - Effects measured
        - lags, transient behaviour
        - interfaces with climate feedbacks (carbon, albedo, surface roughness)
        - equilibria achieved
- Under which circumstances do we produce tipping points?
- Trailing edge of boreal zone – but is this not just mortality model? Lacking representation of drivers (insect pests, climate, fire, etc – to be included later)

General work to be done

- Upscaling of dispersal kernels (Oliver) – different kernel shapes (e.g. Long-tailed), kernels depend on resolution, and also differ for IBM and grid-based models
- Run models across continental transects with different dispersals
  - unlimited in several intensitites
  - only local (does this make sense?)
- explicit dispersal
  - different types of kernels
  - different parameters
- with species vs PFTs
- at points of interest, sensitivity analysis whether tipping point behaviour can be reproduced
- boreal real transects (temperate boreal tundra)
  - Several transects in different parts: TreeMIG, ForGEM, BioMOVE, SEIB, Hybrid, CLM-ED, Takashi (SAS) – which model can be run where, and what is the data availability
    - Canada
    - Western Siberia – permafrost needs to be considered – only CLM-ED
    - Eastern Siberia
    - Europe
    - Miombo forest (aDGVM, SEIB, Hybrid, CLM-ED) - North South
- Comparability
  - 1 km resolution
  - use same drivers
  - No feed back of vegetation
    - disturbances
    - land use
    - perma frost
    - climate
    - vs with feed backs as contained in models
    - Maybe later with IMIC for climate

Open questions

- which other models?
- who coordinates? - DROP BOX
- Who gathers data?
- Overlap with fire group
  - data inputs
- what do you need as data input (ID data needs)
- Protocol
  - output variables

Small outlier populations (i.e. small trees far out) will be addressed stochastically or via dispersal, and via cell properties (land cover, fragmentation)

Heterogeneity in climate / safe sites can be addressed with 1km resolution, and for spatial variability can be accounted for or created.

Null Model: no migration vs. migration. How well known are dispersal kernels for Siberian species? Working with plant functional traits should allow to estimate dispersal kernels, but these are not based on climate information. Suggestion to use 3 dispersal kernels: slow, medium, fast dispersal.

Establishment/survival is the second component of migration, and is already build into the models as simplistic rates and can be adjusted.

Four components to migration: seed production, seed dispersal, establishment and generation time.

Dominant species in Miombo have seed pods that are difficult to disperse, and could prove to be interesting case studies for regional migration.

Get back in touch in Doug in regard to transects and data availability

Parametrisation

- Standard set of simulations for all, then separate runs for species, with and without permafrost
- Oliver will visit Zuerich in the near future to develop dispersal kernel
- For which PFTs / species are dispersal kernels required?
- How to group species?
- Dimension of dispersal kernels – normally probability function, integrated
- Seed production?
- Establishment?
- Stochastic, replicates
- Drivers?

Spin up

SEIB – 2000 years of similation – to get complete vegetation cover, TreeMIG 500 – 600 years

CRU 1961 – 1990/2000 as baseline climate, might not have all data – GCM reanalysis data 1960 – 1990/2000 simulation, repeat period backwards to obtain sufficient

How to get CRU data to resolution required – WorldClim – calculate anomalies and apply these to the resolution required – downscaling either GCM or regional model

Specific information, eg. Vapor-pressure lacking

Pre-industrial CO_2 concentration = 280ppm (if we use this, use corresponding early 20th-century)

or combine climate of 1960 – 1990 with CO_2 concentration of 340ppm → carbon committees, validation with Doug Morton's data

hourly data - daily data – monthly data → downscaling where necessary

wind speed, temperature, precipitation, soil temperature, humidity, cloudiness/radiation/PAR

Incorporation topography – this will influence micro-climate

Simulation time required?

Stochastic, replicates?

- Vegetation
  - initalisation
  - distribution data to fit climate envelopes
  - parametrisation of species/PFTs
  - Dig in the literature for TreeMIG and BioMOVE
- Land use (George Hurtt)
- Disturbances (fire, storms, insects)
- Soil
  - depth, field capacity (50 cm, 100 cm), soil type,, % sand
  - European Soil Map
  - FAO
  - Canadian soil map

Transect – area of Doug Morton's transect – move towards Quebec and make it longer to the south – more detailed information on the transect – however, topography might be too complex – rather move to central Canada, where it is flatter, but more land use => contact Doug on data availability

Western Sibiria – transect close to Ural, to the east

Species data? Pine, birch, larch, Abies – data source? Circumpolar distribution data – Hulten, Zimmermann digitised pine data – PFTs can be extrapolated

Data comparison with Doug's data – semi-automated classifications of 40years of Landsat data (if available, and without cloud cover)

Palaeo-migration speed

Anecdotal evidence

MODIS data

land use maps – natural vs transformed

How to proceed

- sketch
- define transects (with coordinates – Nick + Heike)
- assign responsibilities (for tasks – Cornelia to chase up)
  - Climate – Nick + Heike / Rosie
  - CO_2 – Takashi
  - Vegetation data – Wilfried + Cecile, Nick + Heike (Sibiria) – Doug for classification
  - TRY data – Jens (via Cornelia) → seed production
  - Dispersal Kernels – Oliver
  - Land use – George Hurtt + Takashi
  - Soil – Heike + Cecile (Canada)
  - Disturbances – Doug
  - Dropbox etc – Cornelia
  - Refine proposal – Heike + Cornelia
- time line to get everything ready
  - Data ready / available by end of May

Proposal attached to the report as separate file.

Fire: Southern Africa forest/savanna tipping point (Miombo)

Motivation

- Tree cover of >40% inhibits frequent fire
- Shifts from savanna to forest depends on CO_2 / fire ignition / herbivory / land use but attribution is difficult
- Little work in this region yet, could make a big contribution
- Builds on GBO3 tipping points analysis for Miombo

Questions / Tests

- Does CO_2 fertilization in interaction with fire lead to a shift to forests? (attribution question)
- Can you get the fire regime vegetation / tropical rain forest boundary right? Is this controlled by climate or vegetation? How stable is it?
- Thresholds (CO_2, % tree cover, precip.)?
- What are effects of fire suppression?
- Can models correctly reproduce modern fire regimes?

- Climate / land surface feedbacks (using simple heuristic models vs. fully coupled models)?

Where
South of the Equator (want to include some humid tropical forest)

Models
- Yes: ADGVM (Steve H.), LPJ-Guess-Spitfire (Almut Arneth, Thomas H.), LPJmL - Spitfire (Kirsten), LPX, MC1 (Dominique B., need data sets)
- Maybe: Seib-DGVM (Hisashi), Orchidee-Fire? (Ben), CLM-ED-Spitfire? (Rosie),
- Non-present groups: CTEM - Dominique contacts, *COSMOS-CLM? (for land surface feedbacks - Thomas H. contacts), CLM / JSBACH Fire - Sylvia Closter?,* SDGVM - Paul contacts Ian Woodward - do they have a new fire model, TEM - Paul contacts Jerry Melillo
- Couple with SDMs through habitat (Wilfried?)
- Use of heuristic models to interpret model outputs

Comments:
- Patch vs. non-patch models
- Spitfire vs. non-spitfire models
- Coupled vs. non-coupled (Orchidee / COSMOS-CLM)

Input
- Land use: RCP land use (George H.)
- Modern Climate:
  - Overall - CRU (0.5°), CRUNCEP (**N. Viovy**)
  - Sites - Kruger (rainfall + CRU, with WorldClim) + try to find more data
- Future Climate:
  - AR5
- Soils: Overall - FAO (0.5°) - or use your own favorite data set
- Sites - try to find detailed site specific data
- Veg maps: F. White (better than GLC), Steve H. & Thomas H. know several ancillary datasets, Ben Poulter (PFT maps)
- Traits: TRY, think about variables needed - **Paul writes Jens** would look into TRY and he would search for additional data sets. Steve H. has data on bark thickness.
- Storage: iLAMB - Abramowitz, J Randerson - **Rosie** will contact, **Ben** will also be contact, Paul will follow-up

Validation
1. GFED3 fire data: burnt area (0.5°) - **Doug, Ben P.**
2. Fire exclusion data sets: **Kruger Steve H., others William B.**
3. PFT fraction maps (0.5°) - **Ben P.**
4. Remote sensing woody cover/height data - G. Buccini, NREL - **Steve H.**
5. Photographic data - 1930's- present (S. Africa, **B. Wigley - Paul follows up**)
6. Mid-term - Africa flux tower data - **Paul contacts Markus R. (see Ben about interpolated data)**
7. Tree ring data (see Ben P.)
8. Inversion model CO2 flux (P Bousquet - Dominique)

Contacts: Matt Williams, J. Grace (Exp data on Fire and Mgmt in Miombo woodlands Edinburgh), B. Scholes, W. Bond - would look into Miombo data

Output
- Response variables:
- Length of simulation: 21st century

Iconic Figures
- Tipping points - CO2, precip, % tree cover
- Fire as management tool (in interaction with above)

- Examine both using - Horrible forcing diagrams (Steve)

- Iconic fig 1 (fire as management tests)
    - y axis = tree cover
    - x axis = forcing /
    - Two curves, one with extra fire ignitions and another with ambient fire to test the impact of management as a tool to maintain savanna -

- Iconic fig 2 (initial conditions test)
    - y axis = tree cover
    - x axis = forcing (this could be CO_2 or rainfall or rainfall seasonality)
    - Two curves, one with initial conditions as forest, and another with initial conditions as savanna. One gives more forest in the first place

How to test dry season length

<u>- Same rainfall in shorter time (wide range 4-9 months)</u>

- Less rainfall

Create new data set with modified rainfall

Burned area vs. % Tree cover - when do disturb a forest enough to open it up.

Tree cover or Burned area or Severity (fract biomass loss, or consumed vs. killed, or NPP consumed) vs. precipation - low and high fire

- Some models (Dominique) cannot run in these two modes - maybe use fire duration as a proxy for management. Spitfire can alter emissions sources.
- Collatz model predicts demise of C4 grasses by end of century because of
- Steve - investigate initial conditions dependence by forcing models to have different initial conditions: using initial conditions from other grid points (e.g. use a forest grid cell and turn it into savanna conditions.

<u>Broader "Savanna" project - e.g., Southern Africa, South America, Australia - Intercontinental comparison of fire</u>

- Generalities about drivers of fire
- E.g., Areas with have similar environments, but very different vegetation at dry end of environmental gradient
- E.g., why aren't pampas taken over by trees? where is fire?

<u>Broader fire project, e.g., including Boreal Forest</u>

<u>Amazon forest dieback, fire and importance of additional functional groups</u>

<u>Data Synthesis project</u>

- Data paper fire synthesis, like forest dieback (Allen et al., 2010)

<u>Paul writes Savanna/Forest "box" for IPCC.</u>

CO_2 effect

- Higgins - ADGVM - Huge CO_2
- Woodward - SDGVM - Small CO_2
- Bachelet MC1 - Arid grasslands
- Ciais - Boreal and CO_2
- Bouwman - Forest expansion - CO_2
- Experimental data - S. Africa

CO_2 effects and Palaeo

- Harrison and Prentice - 2003 - Humid forest contraction at LGM - CO_2 effect
- Dupont - Humid forest contraction LGM
- Savannas mostly gone during LGM

Precipitation effect

- Bond (New Phytologist) - no savanna less than 5 months dry period

Ecosystem services

- C storage
- Grazers
- Biodiversity - especially herbaceous

Common strategies for climate drivers

AR4 and shifting to AR5 – RCP land use scenarios

gridded land use products

Global benchmarking project – common data repository – prevent reinventing the wheel → contact details. Some data required might be very specific for the project, but might be created

Odd decoupling of RCP scenarios from climate scenarios, as they are not fully coherent – not clear which land use data sets to get from George → land use scenarios not necessarily constrained by fossil fuel emission – so data sets used need to be coherent for GHG emissions

What land use scenarios are to be used? One that fits with large changes, other with small changes => George

Standard land use scenarios associated with each RCP (2, 4.5, etc) plus variations → 4 scenarios with land use and climate drivers (one land use scenario for each RCP – however, if you want to tease out land use impact, you will need to use land use scenario variants) – narrow down the full range of climate scenarios, and use these for reasonable selection

Just use one scenario for each projections

Peter Lawrence converted land use scenarios into PFTs. - possibility of using these?

AR5 climate scenarios run faster

Obvious place to start with 4 RCP scenarios where data can be obtained fairly quickly