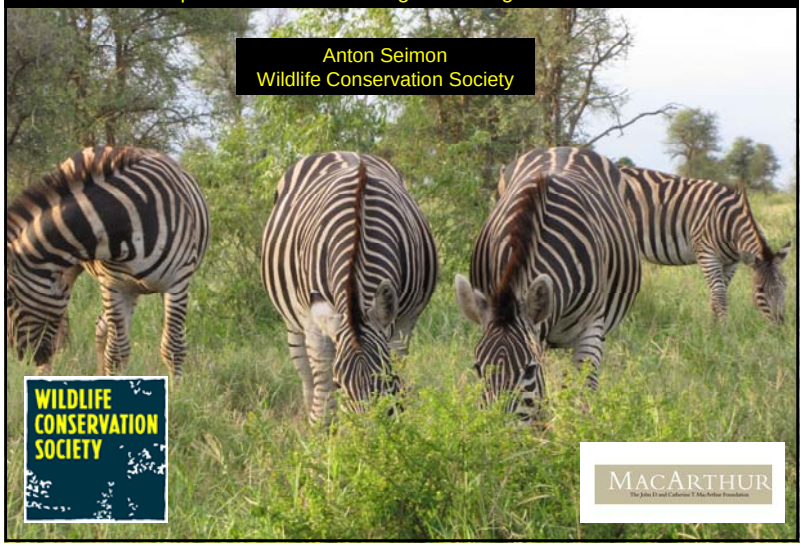
Incorporating Climate Change into Conservation Planning for the SADC Region
Perspectives of a climatologist working in conservation



Some climatology basics

Climate vs. weather
"Climate is what you expect; weather is what you get"

Climatic variability
Fluctuations around baseline means at seasonal, annual and longer time scales

Climate change
Multi-decadal climate trends that shift the baseline

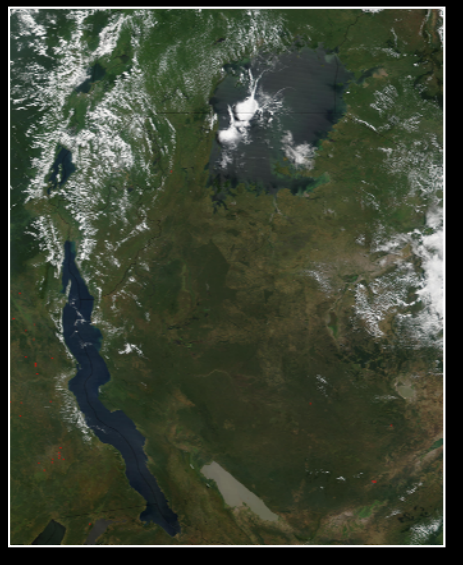
"Global warming"
Ongoing human-caused or enhanced climate change

El Niño-Southern Oscillation (ENSO)
Dominant driver of year to year climatic variability, especially in the tropics

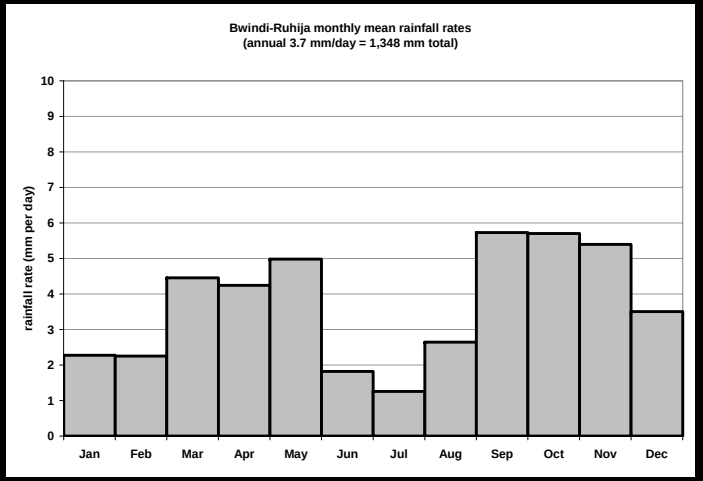
Controls over regional climate

Spatial variability largely governed by topography and land surface type = local forcing

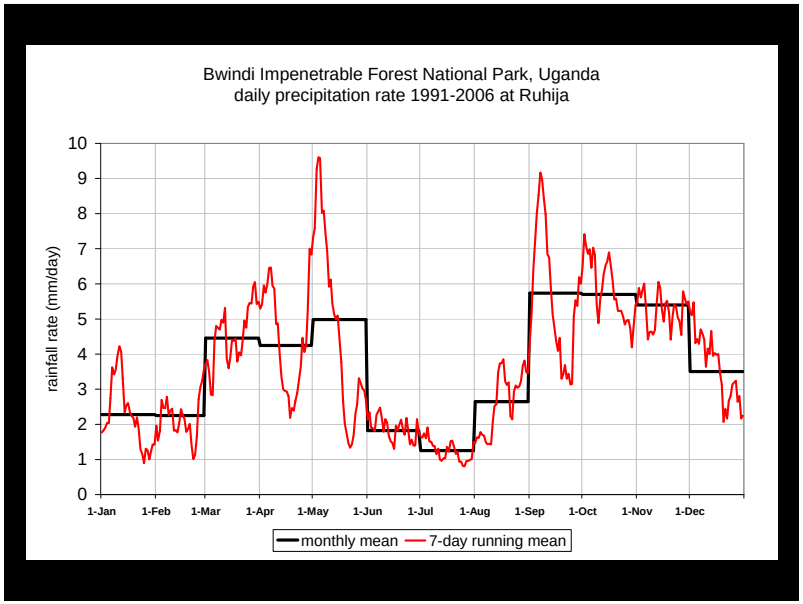
Season to annual variability influenced by factors far outside region, especially sea surface temperature anomalies = external forcings

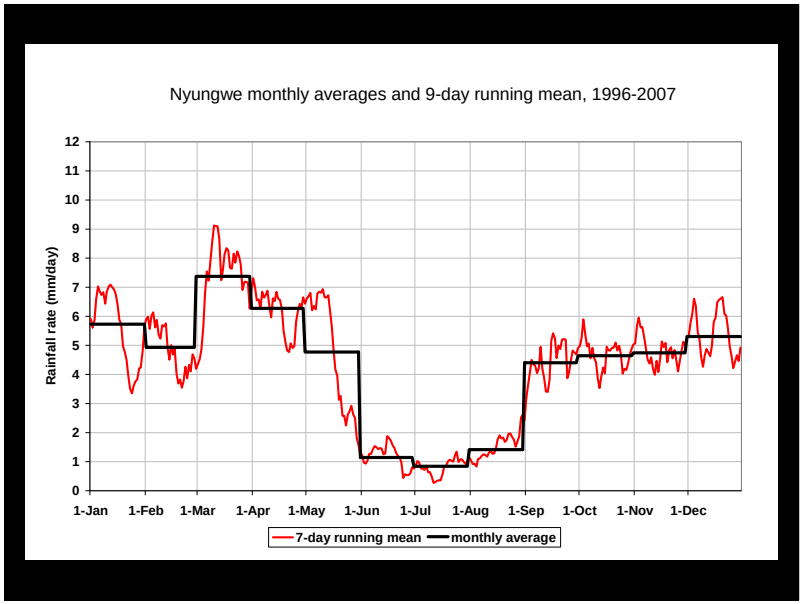


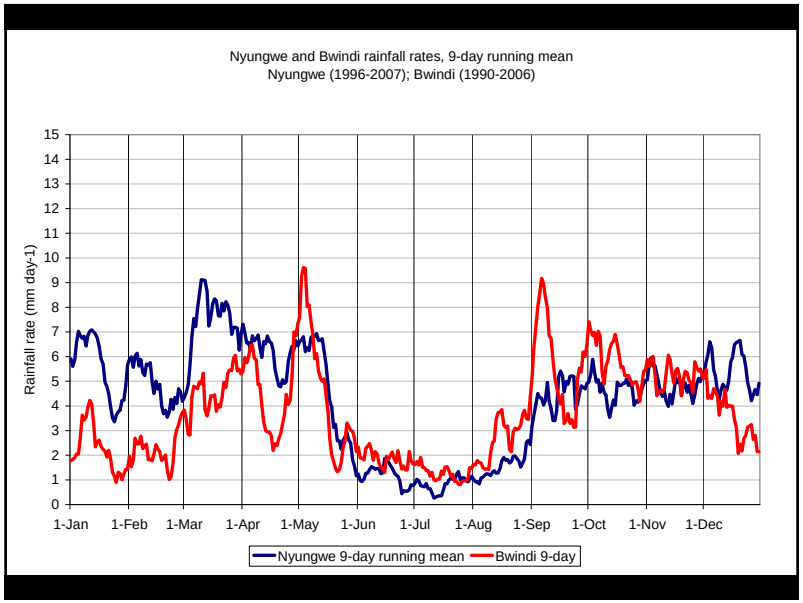
How well do you know your local climate?



Bwindi Impenetrable forest National Park, Uganda







Daily rainfall rate at Mahale smoothed by applying a 21-day running mean
10-year periods 1989-1998 and 1999-2008.
-wetter to drier (red)
-drier to wetter (blue)
from the earlier to the latter period.
Data provided of Dr. Noriko Itoh, Kyoto University.

How to consider climate change relative to current threats?

CC has slow evolution but ultimately will have *severe* impacts

Physical environment
– significantly increased temperatures, probably drier….

Hydrology
– increased desiccation, competition for water resources

Wildlife habitat
– shifting ecotones, changing biomes, species assemblages

Disturbance
– changed fire regimes, potential for fire outbreaks, pests, invasives…

Seasonality
– shift in dry season length, timing of rainfall peaks, etc.

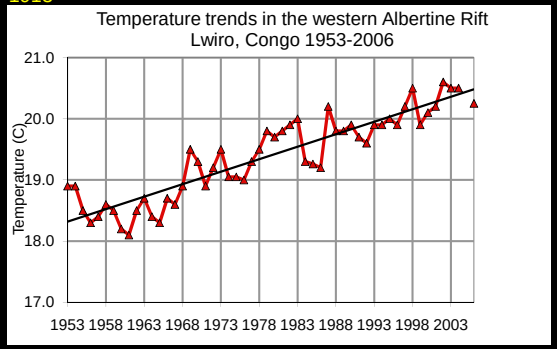
Disease
– the witch's brew of present-day disease + others extending ranges + newly EIDs

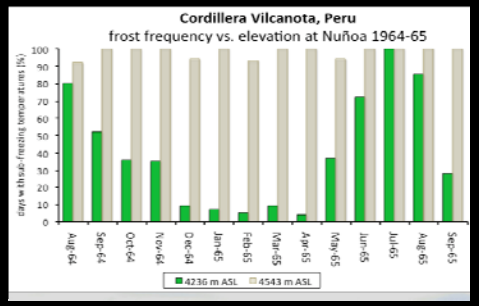
NET RESULT: by mid-late 21st century, greatly changed landscapes for which past experience offers poor analogs

Thermal increase is already strongly throughout the tropics

Example 1: Virunga massif (Rwanda, Uganda and Congo DRC)

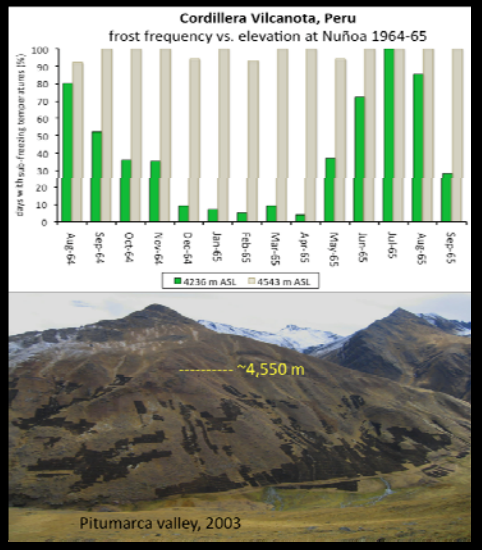
"Karisimbiis the highest peak of the range, being<4,507 m> above sea-level. It is a beautifully formed sharp cone, nearly always snow-covered." E. M. Jack, The Geographical Journal, 1913





Example 2:
Cultivator response to regional warming in Southern Peru over 40 years
- Frost limit at ~4,250 m in 1960s with short growing season
- year-round frosts at 4,543 m

Source: Winterhalder and Thomas, 1978



Source: Hole et al., in press 2010

Changing phenomenology of extreme events

Example: Australia/Melbourne area fires in February 2009

Meteorological conditions unprecedented in more than 100 years of records:
- Highest temperatures ever (48 deg. C)
- Humidity 7%
- Winds gusting to 20 meters per second (40 knots)

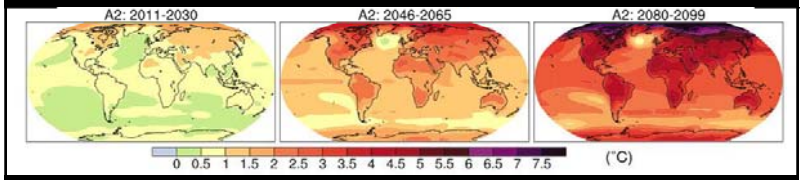
Result: Uncontrollable fires, extremely rapid propagation, total destruction of biota and structures in affected corridors, ~230 fatalities

Bushfire dwarfs a fire-truck at Labertouche, near Pakenham, east of Melbourne. Picture: Alex Coppel
http://www.news.com.au/heraldsun/gallery/0,22010,5037339-5006020-163,00.html

Photo taken by Nick Hill of the Bunyip State forest taken from a property on the Labertouche North Road.
http://www.news.com.au/heraldsun/gallery/0,22010,5037340-5006020-10,00.html

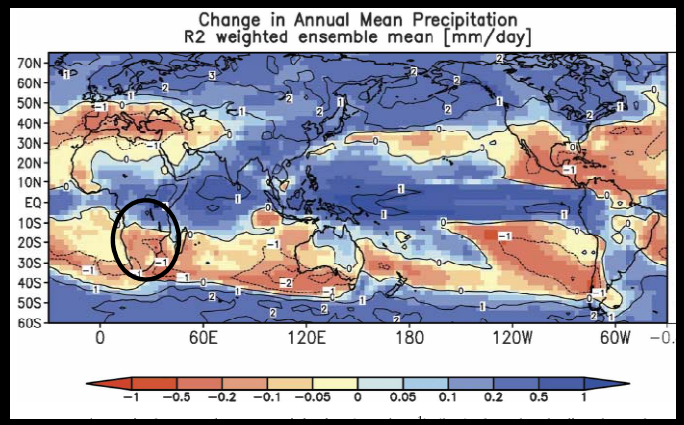
A bushfire burns in the Bunyip State Forest near the township of Tonimbuk. Picture: AAP/Andrew Brownbill
http://www.news.com.au/heraldsun/gallery/0,22010,5037339-5006020-145,00.html

Global warming of the 21st century – IPCC multi-model simulations



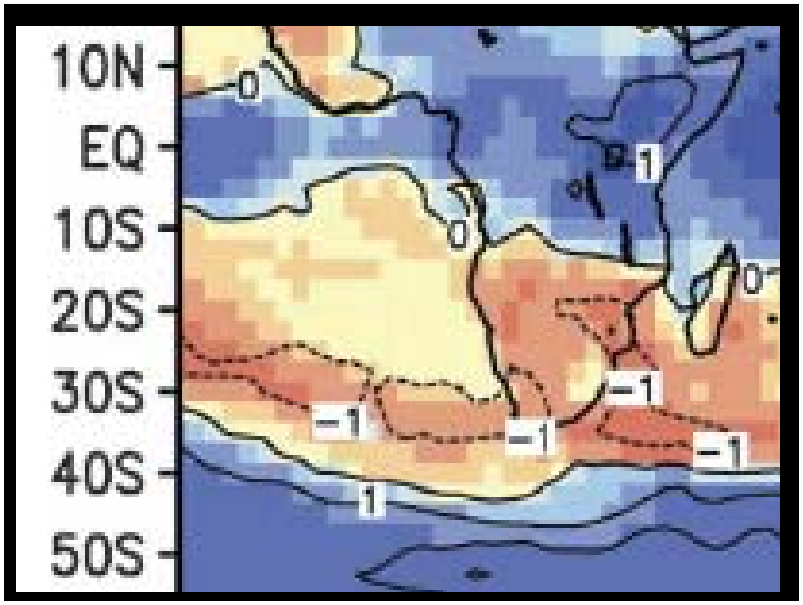
IPCC multi-model projections for end of 21st century compared to present

Global precipitation changes of the 21st century – IPCC multi-model simulations



IPCC multi-model projections for end of 21st century compared to present

Source: Impact of Climate Change on River Discharge Projected by Multimodel Ensemble
Nohara et al. *Journal of Hydrometeorology,* 2006



Climate change and adaptive management for conservation

Climate model output = parameters such as temperature, wind circulation and precipitation

What information do we actually need?

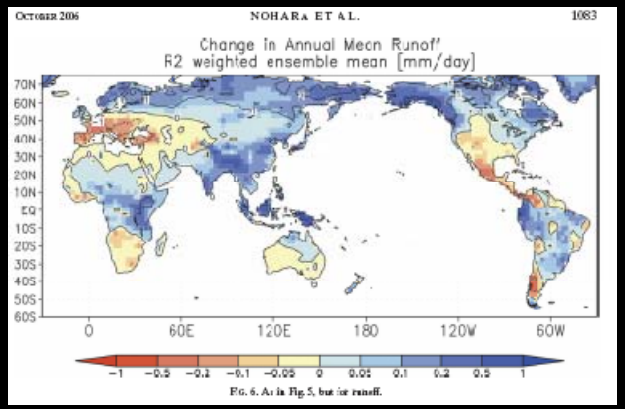
- precipitation amount – *how much will it rain?*
- extreme events – *floods and droughts*
- seasonality – *when will it rain?*
- evaporation – *how much water will be lost from soils, vegetation, water bodies?*
- river flows – *how will they change?*
- grasslands and forests – *will they change in extent and species composition?*
- fire and pests – *how will disturbance regimes change?*
- human/wildlife health – *how will sickness and disease characteristics change?*

-- etc.

Challenge is to create more meaningful products to inform conservation needs

River discharge changes in 2100

derived product combining modeled precipitation and evaporation



Impact of Climate Change on River Discharge Projected by Multimodel Ensemble
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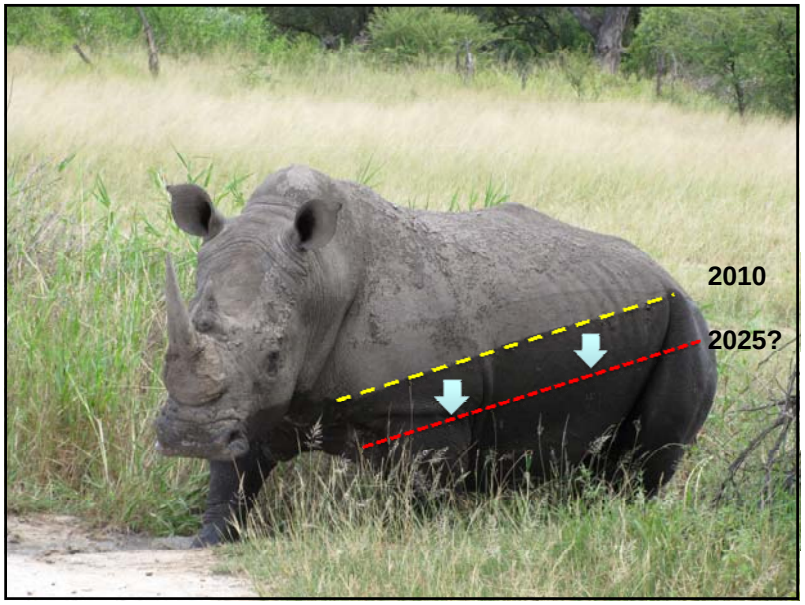


The WCS Albertine Rift Climate Assessment Project (2007-2009)

Climatological analysis and linked climate-vegetation-crop modeling

Output summarized in two whitepapers currently under revision:

1. *Climatological Assessment of the Albertine Rift for Conservation Applications*
2. *Potential Climate Change Impacts in Conservation Landscapes of the Albertine Rift*

All project data and reports will be obtainable from the project website:
http://programs.wcs.org/Resources/Downloads/tabid/2801/Default.aspx

Comprehensive Monitoring for Climate Change Adaptation and Management in the Albertine Rift Protected Area Network (2009-2012)

Three aims:

• to build the human and infrastructural capacity of Albertine Rift countries to collect accurate data about climate, vegetation, and the impact of climate change on wildlife

• prioritize wildlife and habitat migration corridors based on this data and on modeling

• to provide all of this information in readily usable form to policy-makers through reports and briefings for NAPA taskforce teams, protected area authorities, and other implementing agents

Schematic diagram demonstrating the procedure used to generate ecologically meaningful products specific to the Albertine Rift study domain from raw, low resolution GCM output

The WCS Albertine Rift modeling domain showing key conservation landscapes (see http://www.albertinerift.org)

Downscaled climate variables across the entire domain

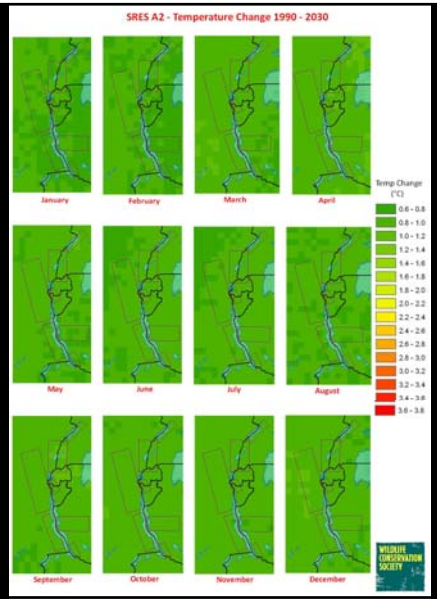
1. Climatological variables
- Monthly mean temperature (°C)
- Monthly mean precipitation amount (mm)
- Monthly mean cloud cover (percent of sky coverage)

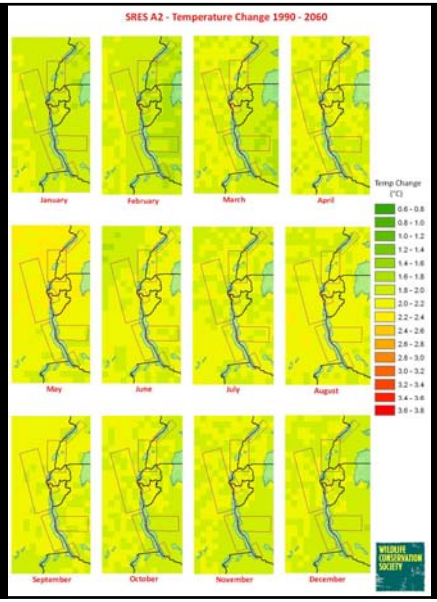
2. Carbon Fluxes
- Net Primary Production (NPP)
- Land-Atmosphere flux
- Carbon Loss from Fire
- Heterotrophic respiration (Rh)

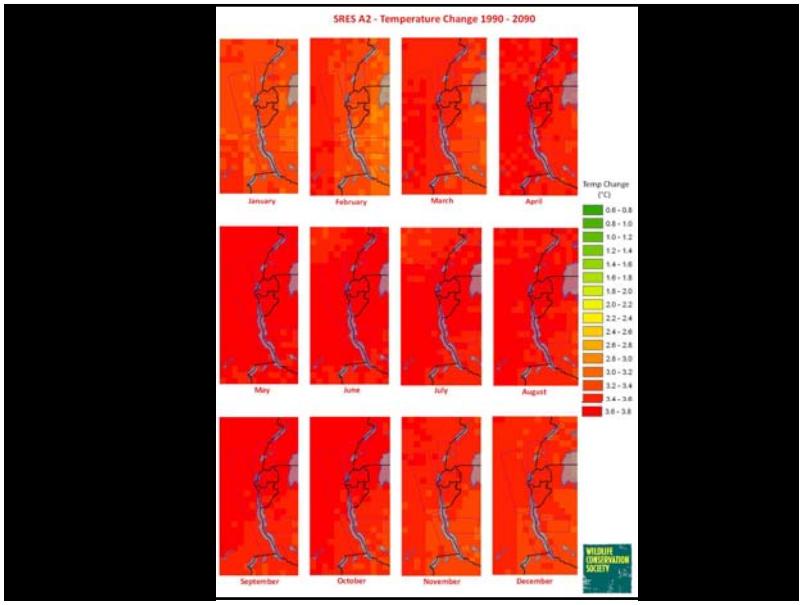
3. Carbon Pools
- Vegetation Carbon
- Soil Carbon
- Litter Carbon
- Annual Total Carbon

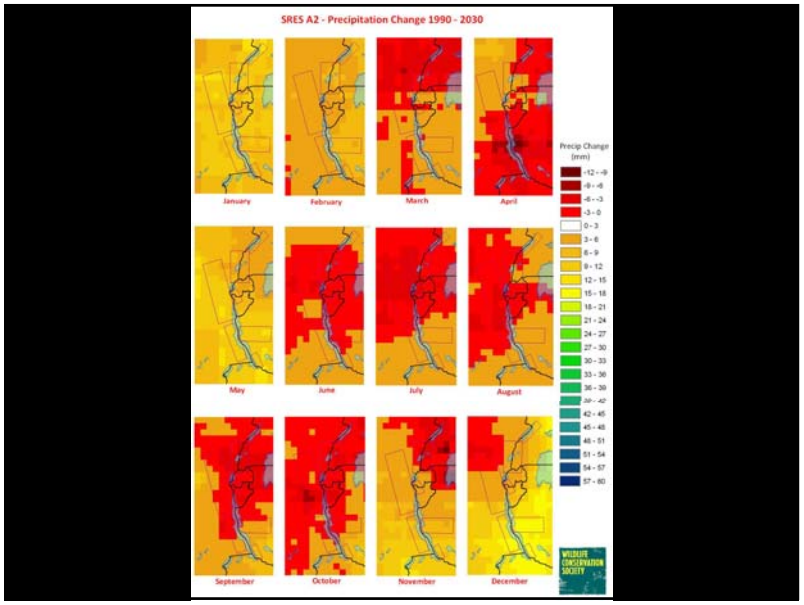
4. Hydrological Variables
- Total Runoff (mm)
- Actual Evapotranspiration (mm)

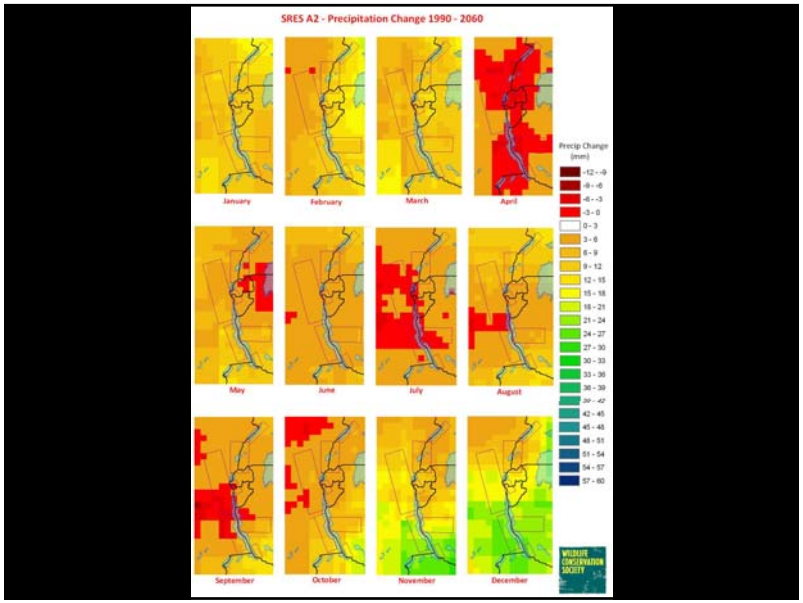
5. Vegetation and agriculture
- Annual Phaseolus Bean Yield (kg ha)
- Annual *Brachiariadecumbens* Yield (kg ha)
- Annual Maize Yield (kg ha)
- Fractional Cover of Plant Functional Type (%)

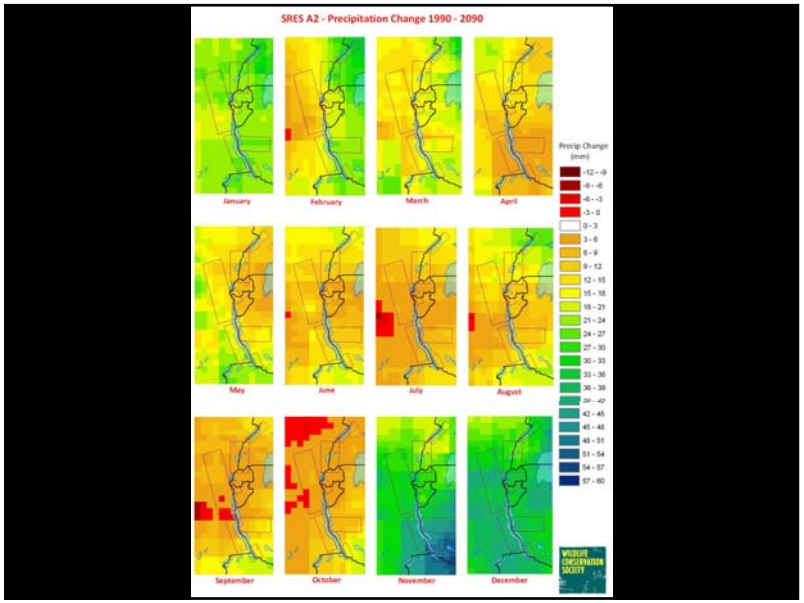


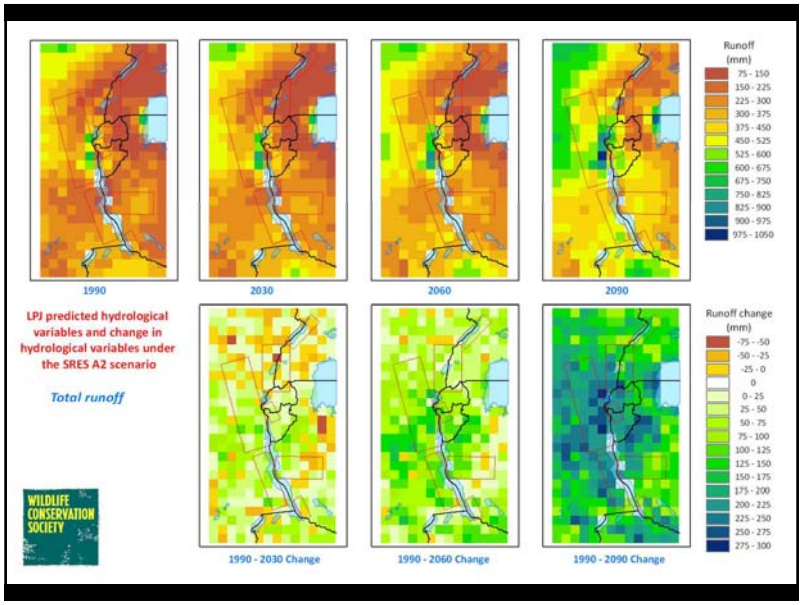


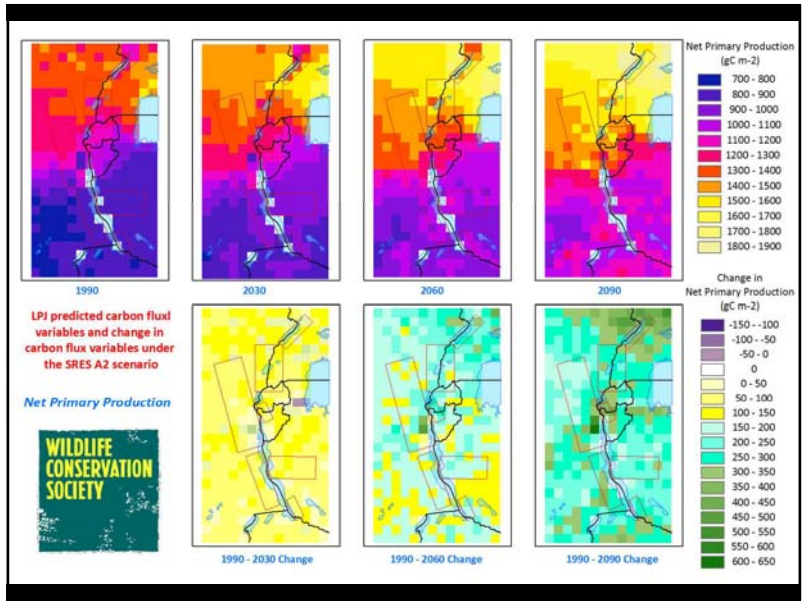

SRES A2 - Temperature Change 1990 - 2090
January
February
March
April
May
June
July
August
September
October
November
December
Temp Change (°C)
0.6 - 0.8
0.8 - 1.0
1.0 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
1.8 - 2.0
2.0 - 2.2
2.2 - 2.4
2.4 - 2.6
2.6 - 2.8
2.8 - 3.0
3.0 - 3.2
3.2 - 3.4
3.4 - 3.6
3.6 - 3.8
WILDLIFE CONSERVATION SOCIETY

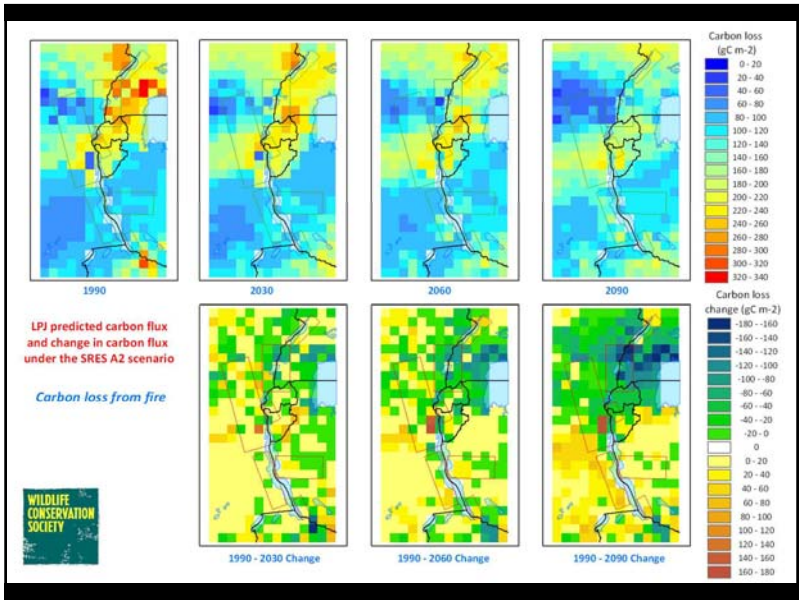

SRES A2 - Precipitation Change 1990 - 2030
January
February
March
April
May
June
July
August
September
October
November
December
Precip Change (mm)
-12 - -9
-9 - -6
-6 - -3
-3 - 0
0 - 3
3 - 6
6 - 9
9 - 12
12 - 15
15 - 18
18 - 21
21 - 24
24 - 27
27 - 30
30 - 33
33 - 36
36 - 39
39 - 42
42 - 45
45 - 48
48 - 51
51 - 54
54 - 57
57 - 60
WILDLIFE CONSERVATION SOCIETY

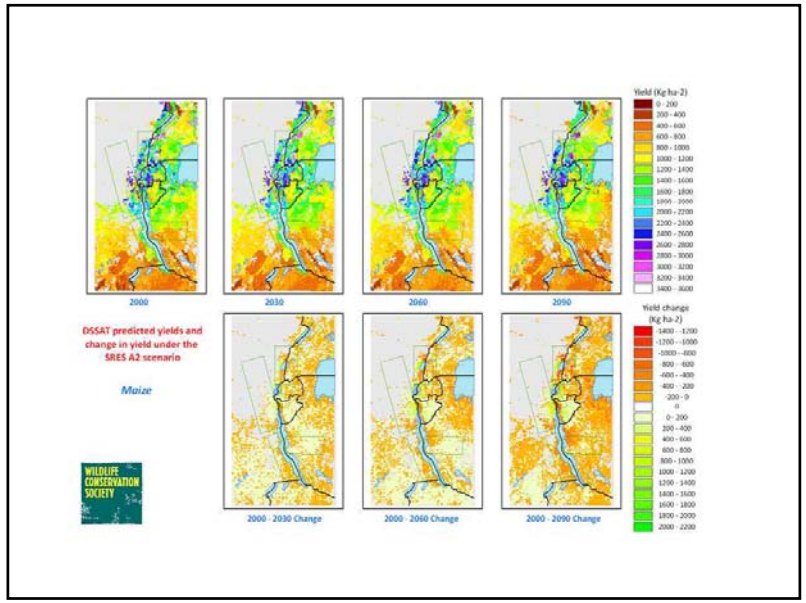

SRES A2 - Precipitation Change 1990 - 2060
January
February
March
April
May
June
July
August
September
October
November
December
Precip Change (mm)
-12 - -9
-9 - -6
-6 - -3
-3 - 0
0 - 3
3 - 6
6 - 9
9 - 12
12 - 15
15 - 18
18 - 21
21 - 24
24 - 27
27 - 30
30 - 33
33 - 36
36 - 39
39 - 42
42 - 45
45 - 48
48 - 51
51 - 54
54 - 57
57 - 60
WILDLIFE CONSERVATION SOCIETY


SRES A2 - Precipitation Change 1990 - 2090
January
February
March
April
May
June
July
August
September
October
November
December
Precip Change (mm)
-12 - -9
-9 - -6
-6 - -3
-3 - 0
0 - 3
3 - 6
6 - 9
9 - 12
12 - 15
15 - 18
18 - 21
21 - 24
24 - 27
27 - 30
30 - 33
33 - 36
36 - 39
39 - 42
42 - 45
45 - 48
48 - 51
51 - 54
54 - 57
57 - 60
WILDLIFE CONSERVATION SOCIETY


Runoff (mm)
75 - 150
150 - 225
225 - 300
300 - 375
375 - 450
450 - 525
525 - 600
600 - 675
675 - 750
750 - 825
825 - 900
900 - 975
975 - 1050
1990
2030
2060
2090
LPJ predicted hydrological variables and change in hydrological variables under the SRES A2 scenario
Total runoff
Runoff change (mm)
-75 - -50
-50 - -25
-25 - 0
0
0 - 25
25 - 50
50 - 75
75 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
250 - 275
275 - 300
1990 - 2030 Change
1990 - 2060 Change
1990 - 2090 Change
WILDLIFE CONSERVATION SOCIETY

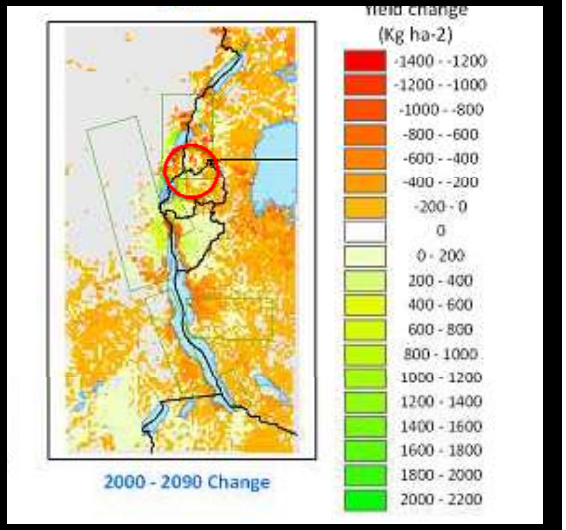

Net Primary Production (gC m-2)
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1300
1300 - 1400
1400 - 1500
1500 - 1600
1600 - 1700
1700 - 1800
1800 - 1900
1990
2030
2060
2090
LPJ predicted carbon fluxl variables and change in carbon flux variables under the SRES A2 scenario
Net Primary Production
Change in Net Primary Production (gC m-2)
-150 - -100
-100 - -50
-50 - 0
0
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
350 - 400
400 - 450
450 - 500
500 - 550
550 - 600
600 - 650
1990 - 2030 Change
1990 - 2060 Change
1990 - 2090 Change
WILDLIFE CONSERVATION SOCIETY

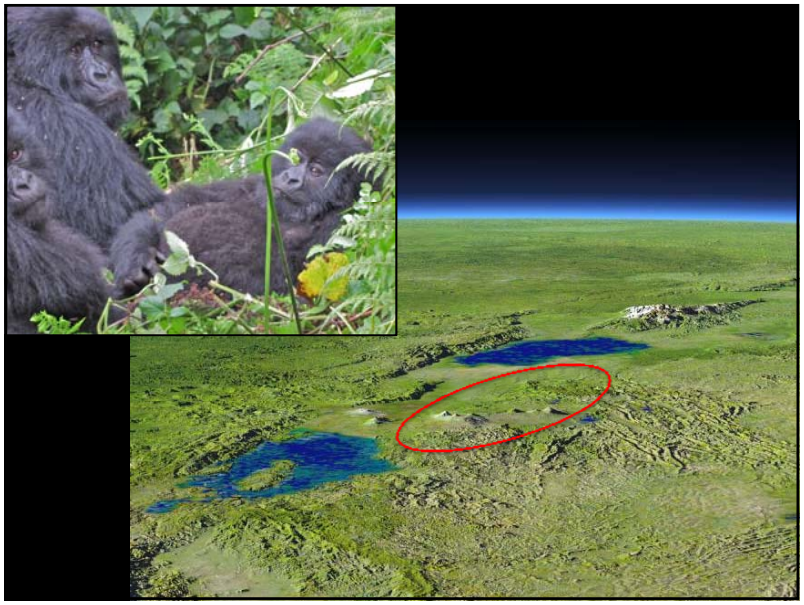

Carbon loss (gC m-2)
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 160
160 - 180
180 - 200
200 - 220
220 - 240
240 - 260
260 - 280
280 - 300
300 - 320
320 - 340
1990
2030
2060
2090
LPJ predicted carbon flux and change in carbon flux under the SRES A2 scenario
Carbon loss from fire
Carbon loss change (gC m-2)
-180 - -160
-160 - -140
-140 - -120
-120 - -100
-100 - -80
-80 - -60
-60 - -40
-40 - -20
-20 - 0
0
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 160
160 - 180
1990 - 2030 Change
1990 - 2060 Change
1990 - 2090 Change
WILDLIFE CONSERVATION SOCIETY

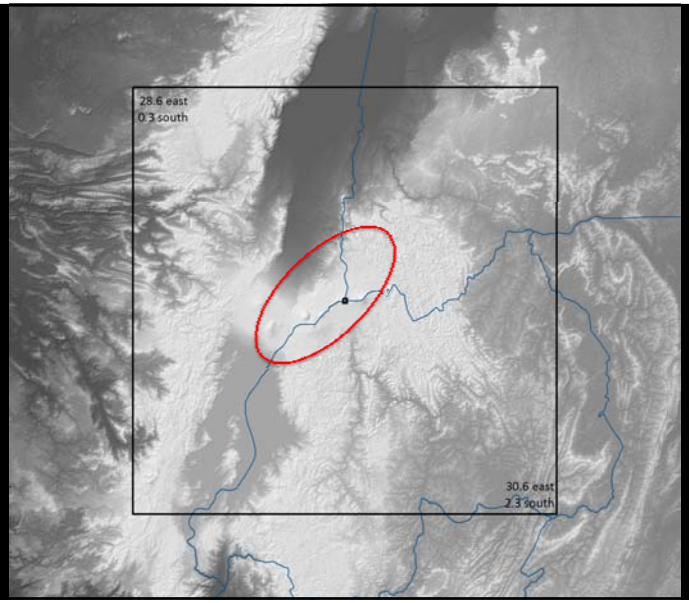

Yield (Kg ha-2)
2000
2030
2060
2090
DSSAT predicted yields and change in yield under the SRES A2 scenario
Maize
Yield change (Kg ha-2)
2000 - 2030 Change
2000 - 2060 Change
2000 - 2090 Change
WILDLIFE CONSERVATION SOCIETY

Modeled change in ***maize*** yield by 2090 under the A2 IPCC scenario

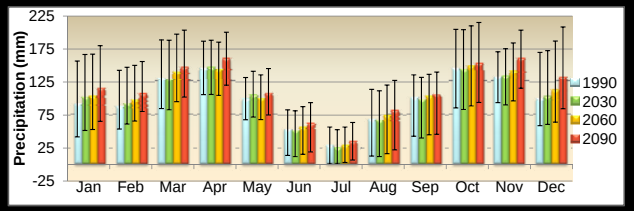
→Increased pressure on mountain gorilla domain as a consequence of yield reductions elsewhere?



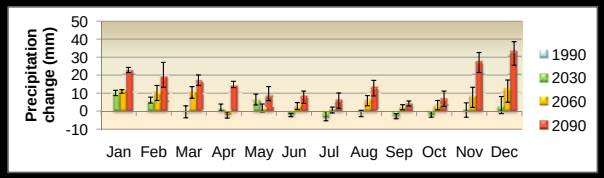




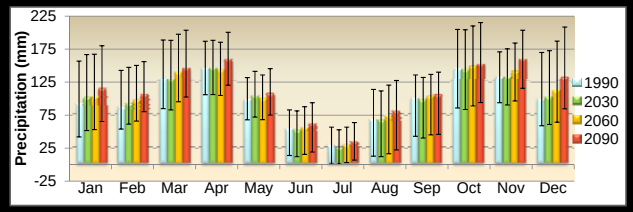
Mountain Gorilla Domain
IPCC 21st century predicted rainfall trends
A2 emissions scenario

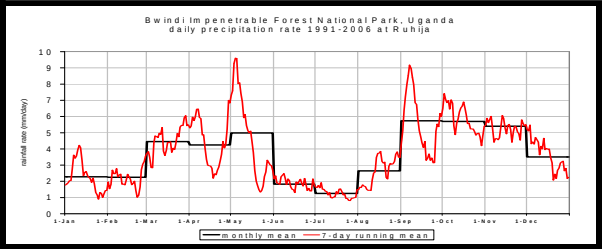


monthly rainfall

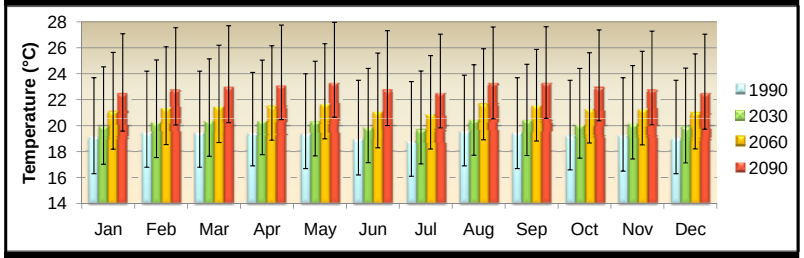


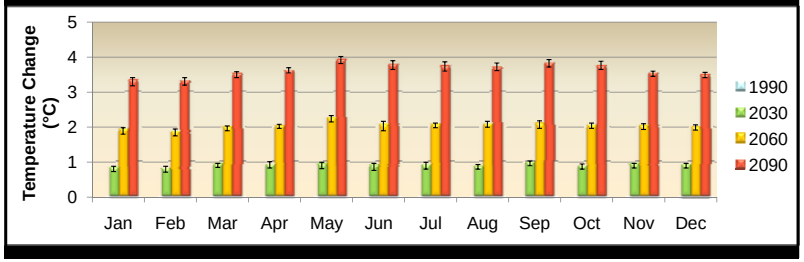
rainfall change relative to 1990 means





Temperature seasonality across the mountain gorilla domain: 1990-2090 (A2 scenario)



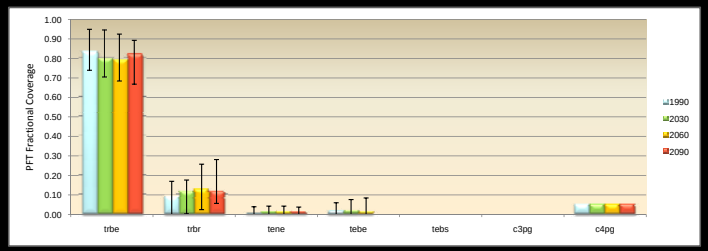


Plant Functional Type across the mountain gorilla domain: 1990-2090 (A2 scenario)

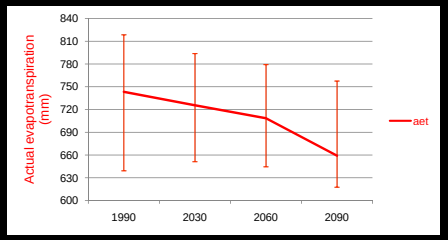
- Currently dominated by ***Tropical Broadleaf Evergreen*** (84%)
  with ***Tropical Broadleaf Raingreen***(10%)

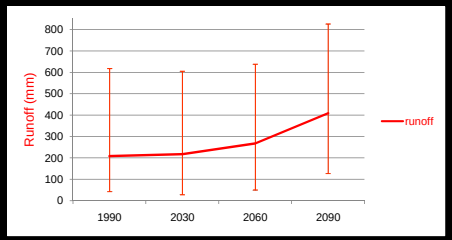
- Very little change indicated over the century across the domain

--Suggests that existing forests will remain extant



A2 scenario vegetation response – mountain gorilla domain





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