Okavango River Basin Transboundary Diagnostic Analysis Technical Report

OKACOM

The Permanent Okavango River Basin Water Commission

Okavango River Basin Environmental Flow Assessment Scenario Report: Biophysical predictions Climate Change Indicator Results (Volume 4 of 4) Report No: 07/2009

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Environmental protection and sustainable management of the Okavango River Basin

EPSMO

ENVIRONMENTAL FLOW ASSESSMENT SERIES

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List of reports in report series

Report 01/2009: Project Initiation Report
Report 02/2009: Process Report
Report 03/2009: Guidelines for data collection, analysis and scenario creation
Report 04/2009: Delineation Report
Report 05/2009: Hydrology Report: Data and models
Report 06/2009: Scenario Report: Hydrology (2 volumes)
Report 07/2009: Scenario Report: Ecological and social predictions (4 volumes)
Report 08/2009: Final Report

Other deliverables:
DSS Software
Process Management Team PowerPoint Presentations

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Executive Summary

The Okavango River Basin Commission, OKACOM, initiated a project titled the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO). This was approved by the United Nations Development Program (UNDP), to be executed by the United Nations Food and Agriculture Organization (FAO). The standard UNDP process is a Transboundary Diagnostic Analysis followed by a Strategic Action Programme of joint management to address threats to the basin's linked land and water systems. Because of the pristine nature of the Okavango River, this approach was modified to include an Environmental Flow Assessment (EFA). To complete the EFA, EPSMO collaborated with the BIOKAVANGO Project at the Harry Oppenheimer Okavango Research Centre of the University of Botswana, in 2008 to conduct a basin-wide EFA for the Okavango River system.

This is report number 7 (Volume 4) in the report series for the EFA. In support of Volume 3, it provides graphs of how each biophysical and social indicator is predicted to change under the three water-resource development scenarios.

Table of Contents

List of Figures

Plus: Time-series graphs for each indicator.

List of Tables

Acronyms and abbreviations

DWAF	Department of Water Affairs and Forestry
EFA	Environmental Flow Assessment
EPSMO	Environmental Protection and Sustainable Management of the Okavango River Basin
Ha	hectare
HOORC	Harry Oppenheimer Okavango Research Centre
IUA	Integrated Units of Analysis
PD	Present Day
SAP	Strategic Action Programme
TDA	Transboundary Diagnostic Analysis

1. INTRODUCTION

1.1. Project background

The origin of the project is described in Report 01/2009: Project Initiation Report. Essentially, an OKACOM initiative titled the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) project was approved by the United Nations Development Program (UNDP), to be executed by the United Nations Food and Agriculture Organization (FAO). In 2008 it collaborated with the Biokavango Project at the Harry Oppenheimer Okavango Research Centre (HOORC) of the University of Botswana, to conduct a basin-wide Environmental Flows Assessment (EFA) for the Okavango River system. This would be a major part of a standard UNDP process: a Transboundary Diagnostic Analysis (TDA) followed by a Strategic Action Programme (SAP) of joint management to address threats to the basin's linked land and water systems. In the case of the Okavango Basin, the standard approach, designed for rehabilitating degraded rivers, would be modified because of the near-pristine nature of the river ecosystem.

The EFA began with a Planning Meeting in July 2008 and was finalised in June 2009. It used mainly existing knowledge and understanding of the river ecosystem and its users. It was generally acknowledged that this was a first, low-confidence, trial run of an EFA for this system, which should be followed by a more comprehensive and long-term exercise where important missing data and knowledge could be addressed to provide higher-confidence predictions.

1.2. Objectives of the EF assessment

There were two main objectives.

- Complete a basin-wide EFA of the Okavango River system as a major part of the wider Technical Diagnostic Analysis. This would be done through several subsidiary objectives:
    - Collate all existing hydrological data on the river system and set up a basin hydrological model that could simulate flows under various possible future Scenarios
    - Reach agreement with the three riparian governments on the scenarios to be explored
    - Bring together specialists in a range of relevant disciplines from across the basin to share knowledge and data, and reach consensus on the:
        - relationships between flow and a series of biophysical indicators of the river system
        - relationships of the condition of the ecosystem and social indicators
    - Develop a DSS that would capture these relationships and produce predictions of ecological and social change for each scenario that would complement the macroeconomic predictions emanating from a separate exercise
    - Incorporate the EFA findings in the TDA document.
- Promote basin-wide communication and collaboration, and build capacity in collaborative basin-wide Integrated Water Resource Management in all disciplines in all three countries. This was done by appointing a full biophysical and socio-economic team from each of the three countries, with planning, coordination and training done by a Process Management Team.

To this was added a further aim – to assess how climate change might affect the prediction of development-driven change.

1.3. The scenarios

Through a process of government consultation, three scenarios of increasing water-use were chosen for the EFA, viz. low, medium and high water use. The details are provided in Report 06/2009: Scenario Report: Hydrology, and in Volume 1 and 2 of this report.

The impact of Climate Change on two of these scenarios, low and medium water use, was also tested in a separate exercise. The details of these assessments are provided in Report 06/2009: Scenario Report: Hydrology, and in Volume 3 of this report.

1.4. Presentation of the results

1.4.1 Rivers and delta

For each scenario, the predicted changes in the river and delta are evaluated in three ways:

1. time-series of abundance, area or concentration of key indicators (see list in Chapter) under the flow regime resulting from the low and medium scenarios each with two levels of climate change (This report);
2. estimated mean percentage changes from present day in the abundance, area or concentration of key indicators (This report);
3. estimated change in discipline-specific integrity, relative to present day and to the low and medium scenarios with no climate change (Volume 3)
4. estimated change in overall ecological integrity, relative to present day and to the low and medium scenarios with no climate change (Volume 3).

1.4.2 Societal wellbeing

For each scenario the predicted changes to socio-economic wellbeing are measured in the following ways:

1. time-series of production measure (catch, harvest or output) of key socio-economic indicators (see list in Chapter 2) under the flow regime resulting from each scenario;
2. estimated mean percentage changes from present day in production measure (catch, harvest or output) of key indicators;
3. estimated change in terms of livelihoods (net income or wellbeing) measured in national currency, for key indicators;
4. estimated change in terms of contribution to national income of basin countries (change in gross national income), measured in national currency, for key indicators.

1.5. Layout of the report

Chapter 1: Introduction.
Chapter 2: A summary of the biophysical and social indicators considered.
Chapter 3: Biophysical predictions for the low scenario with and without climate change.
Chapter 4: Biophysical predictions for the medium scenario with and without climate change.

1.6. The location of the ecological sites and links with IUAs

The number, and to some extent the position, of the eight biophysical sites was dictated by financial, time and safety constraints, and they did not represent the entire basin. The locations of the eight sites, chosen in an exercise described in Report 04/2009: Delineation Report, are given in Table 1.1 and Figure 1-1.

Each biophysical site corresponded to a wider, socio-economic Integrated Unit of Analysis (IUA; Figure 1-1), where it was used to represent the predicted river changes that would affect people.

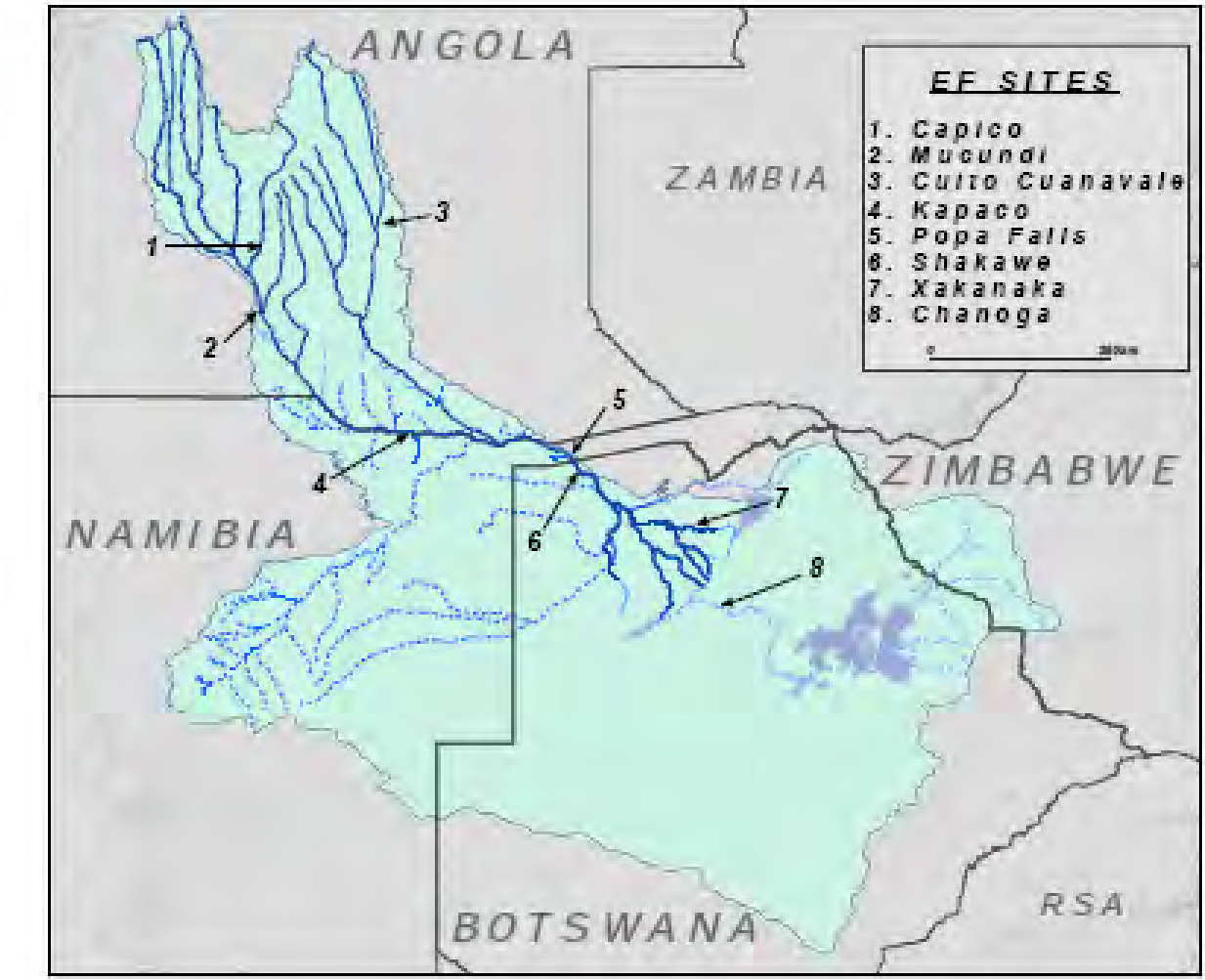


Figure 1-1 Map showing site locations

Table 1.1 The Environmental Flow (EF) sites and their corresponding socio-economic Integrated Unit of Analysis (IUA)

EF Site	EF Site name	Coordinates	Socio-economic IUA
1	Cuebe @ Capico	15˚33'05"S; 17˚34'00"E	3
2	Cubango @ Mucundi	16˚13'05"S; 17˚41'00"E	2
3	Cuito @ Cuito Cuanavale	15˚10'11"S; 19˚10'06"E	6
4	Okavango @ Kapako	17˚49'07"S; 19˚11'44"E	8
5	Okavango @ Popa Falls	18˚07'02"S; 21˚35'03"E	9
6	Okavango @ Panhandle	18˚21'16"S; 21˚50'13"E	10
7	Okavango Delta @ Xaxanaka	19˚11'09"S; 23˚24'48"E	11
8	Boteti	20˚12'51"S; 24˚07'37"E[1]	12

[1] Whole river is the site. Bridge crossing provided as reference.

2. Indicators

2.1.1 The nature and purpose of indicators

In this EFA two kinds of indicators are used: biophysical and socioeconomic. They represent attributes of the ecological and social system that are thought to be either directly or indirectly linked to the river and its flow regime. Their predicted changes as flows change provide a composite picture of the ecological and social impacts of the chosen water-resource developments.

2.1.2 Biophysical indicators

Biophysical indicators are attributes of the river ecosystem that can be described in terms of abundance (e.g. number of elephants), area (e.g. area of exposed sand banks), concentration (e.g. nitrates, conductivity) or cover (e.g. vegetation communities.

Those chosen by the biophysical team for use in this project are listed in Table 2.1.

Table 2.1 Biophysical indicators used in the EPSMO/BIOKAVANGO EF process

Discipline	Sites	Indicators used
Geomorphology	1-6	Extent - exposed rocky habitat
		Extent - coarse sediments
		Cross sectional area of channel
		Extent of backwaters
		Extent of vegetated islands
		Sand bars at low flow
		Percentage clays on floodplain
		Extent of inundated floodplain
		Inundated Pools and Pans
		Extent of cut banks
	7	Carbon sequestration
Water Quality	1-8	pH
		Conductivity
		Temperature
		Turbidity
		Dissolved oxygen
		Total nitrogen
		Total phosphorus
		Chlorophyll a
Vegetation	1-6	Channel macrophytes
		Lower wet bank (hippo grass, papyrus)
		Upper wet bank 1 (reeds)
		Upper wet bank 2 (trees, shrubs)
		River dry bank
		Floodplain dry bank
		Floodplain residual pools
		Lower floodplain
		Middle floodplain (grasses)
		Upper floodplain (trees,)
	7	Open waters
		Permanent swamps
		Lower floodplain
		Upper floodplain
		Occasionally flooded grassland
		Sporobolus islands
		Riparian woodland, trees

Discipline	Sites	Indicators used
		Savanna and scrub
	8	Open water
		Riparian woodland, trees
Macroinvertebrates	1-8	Channel-submerged vegetation
		Channel-marginal vegetation
		Channel-fine sediments
		Channel-cobbles, boulders
		Channel rapid, fast flowing
		Channel-pools
		Floodplain-marginal vegetation
		Floodplain-pools, backwaters
	Plus for 7	Mopane woodland-pools
Fish	1-8	Fish resident in river
		Migrate floodplain small fish
		Migrate floodplain large fish
		Fish-sandbank dweller
		Fish-rock dweller
		Fish-marginal vegetation
		Fish in backwaters
Wildlife	1-8	Semi Aquatics (hippos, crocodiles)
		Frogs, river snakes
		Lower floodplain grazers
		Middle floodplain grazers
		Outer floodplain grazers
Birds	1-8	Piscivores - open water
		Piscivores - shallow water
		Piscivores and invertebrate feeders
		Specialists - floodplains
		Specialists - water lilies
		Specialists - fruit trees
		Breeders - reedbeds, floodplains
		Breeders - overhanging trees
		Breeders - banks
		Breeders - rocks, sandbars

2.1.3 Social indicators

The economic activities in the basin were identified and described. They were then examined and assessed to select those that might exhibit measurable value change if the river/wetland system would be subjected to flow change. These were then used as the socio-economic indicators in the EFA process. Figure 2-1 shows the full list of socio-economic indicators. Most indicators are applicable to all of the eight field study sites and 12 IUAs in the basin. The exceptions apply where, for example, there is no floodplain of significance, and thus no floodplain grazing or floodplain crop production, or where, for example, there are no resident people.

It is important to stress that the indicators selected are limited to values that are expected to change under differing water use scenarios. Some natural resource uses associated with the riverine environment provide livelihood and economic value but are unlikely to change with flow change. An example is use of riparian tree fruits, and another is irrigated commercial agricultural production. Some 2,600 hectares are irrigated in this way in the Namibian basin, contributing significant income and employment for local residents. But irrigated crop production draws water regardless of flow change. New irrigation will also form part of water use development scenarios, itself affecting water flow.

Figure 2-1 List of socio-economic indicators used in the EFA and their links to the broader economy

Possible indicators affecting human wellbeing are those related to health and disease, such as malaria, bilharzia and diarrhoea, were examined. Although their incidence is linked to the aquatic environment these were found to not be affected specifically by flow change. Other possible indicators included natural resource uses such as water lily use (*Nymphaea* sp.) for food, and use of the sedge (*Cyperus papyrus*) for mat making, were rejected as indicators either because they were considered of small import or because in some sites their use was unlikely to be affected by flow changes. Further, not all indicators have been assigned values. Where data are unavailable some relatively minor resources have been treated only in discussion, despite being recognised as possibly responsive to flow change.

The indicators in Figure 2-1 are divided firstly into those affecting both local household income, or livelihoods (indicators 1 to 8) and the broader economy, and secondly those impacting directly on the broader economy or on societal well-being (9.1 to 9.4). The figure shows how these all contribute ultimately to overall social and economic wellbeing.

3. LOW SCENARIO WITH AND WITHOUT CLIMATE CHANGE

3.1. Geomorphology

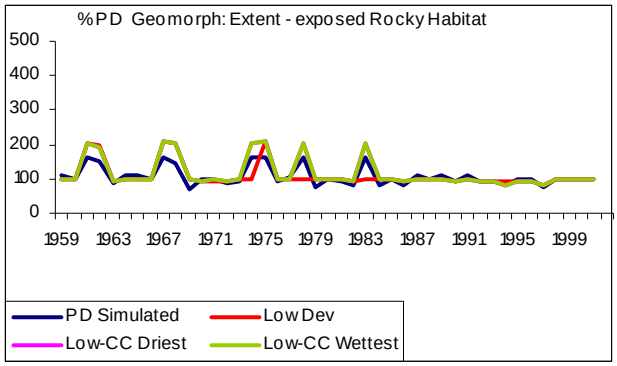
This section provides the time-series of area of geomorphology indicators under the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Extent - exposed rocky habitat
- Extent - coarse sediments
- Cross sectional area of channel
- Extent of backwaters
- Extent of vegetated islands
- Sand bars at low flow
- Percentage clays on floodplain
- Extent of inundated floodplain
- Inundated Pools and Pans
- Extent of cut banksCarbon sequestration.

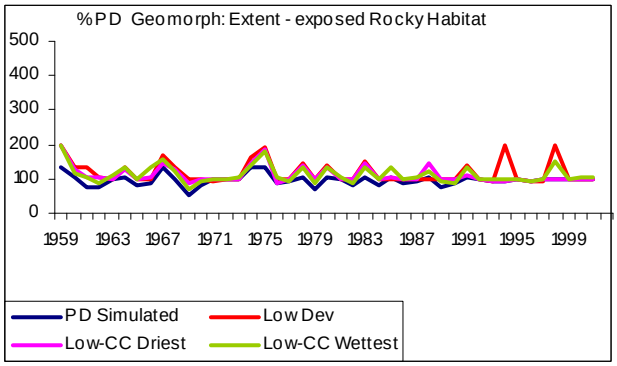
3.1.1 Extent - exposed rocky habitat

(Extent of exposed rocky habitat during the low flow season.)- Not considering the impacts of sediment deposition covering bedrock exposures; only considering the exposed bedrock above the water surface.

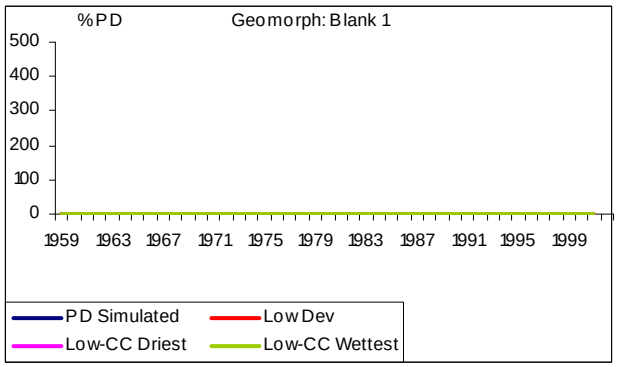
Site 1: Cubango River @ Capico



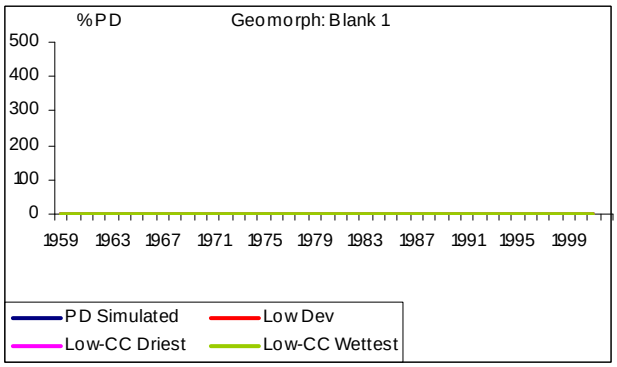
Site 2: Cubango River @ Mucundi



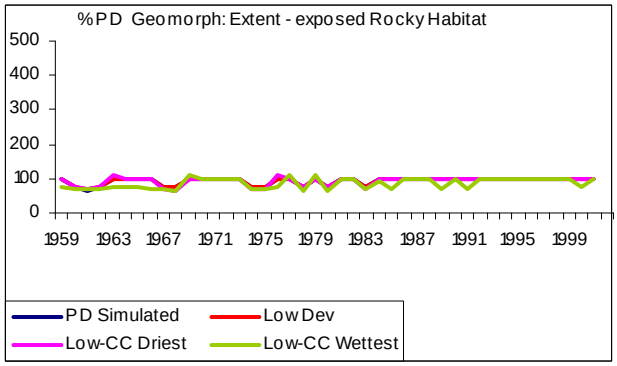
Site 3: Cuito River @ Cuito Cuanavale



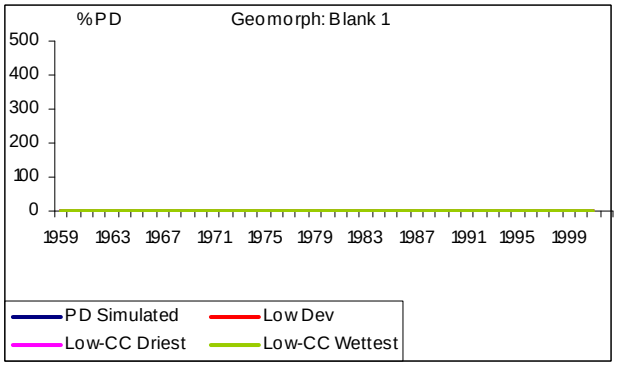
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

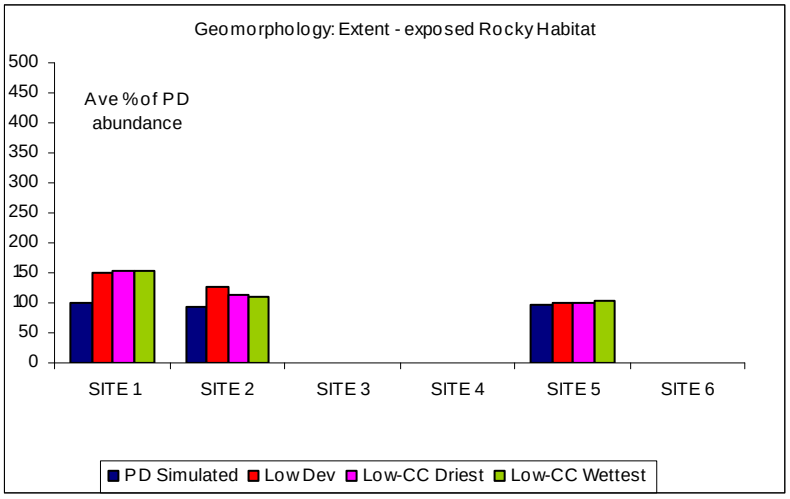


Site 6: Okavango River @ Pan Handle



Summary change per scenario

There is a direct relationship between flow level and rocks exposed above water level. As water level rises, less rocky area is exposed.



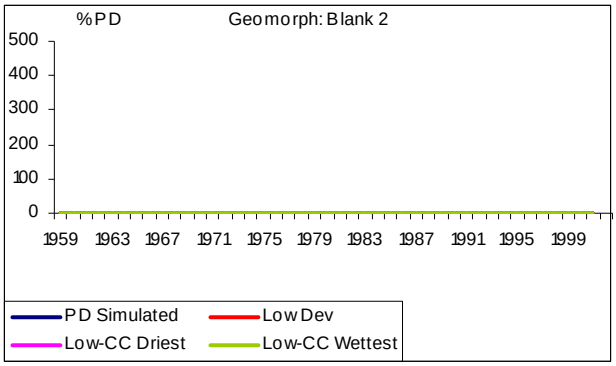
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

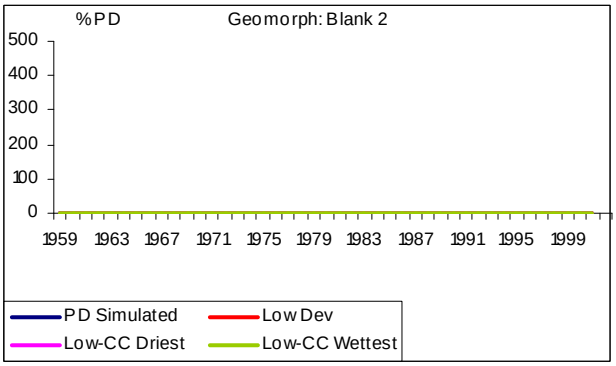
3.1.2 Extent of coarse sediments

(Extent of coarse sediments on the bed)- The bulk of the sediment load is in the range of particle size 0.25 to 0.4mm. This is fine sand that was originally deposited by wind and later reworked by water. Suspended load is much smaller in volume and consists of silt and clay sized particles.

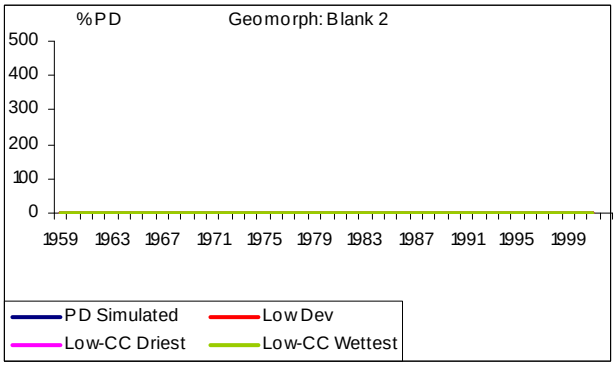
Site 1: Cubango River @ Capico



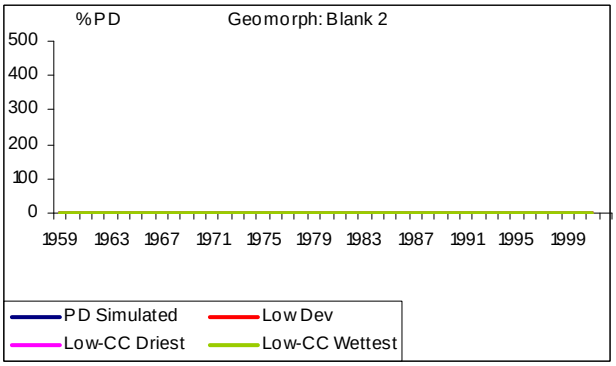
Site 2: Cubango River @ Mucundi



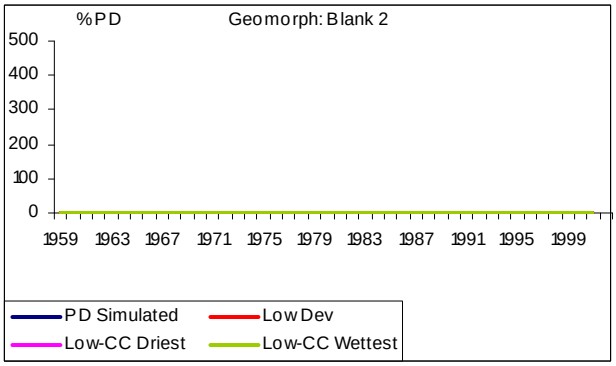
Site 3: Cuito River @ Cuito Cuanavale



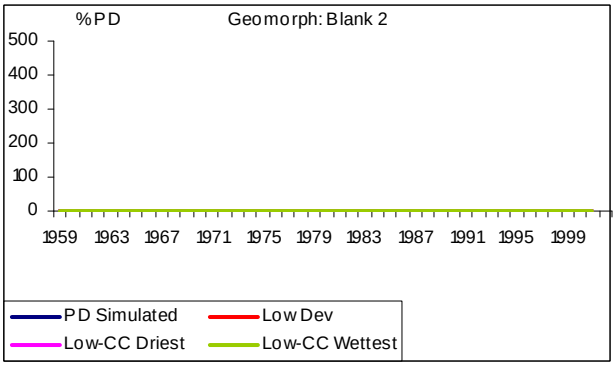
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

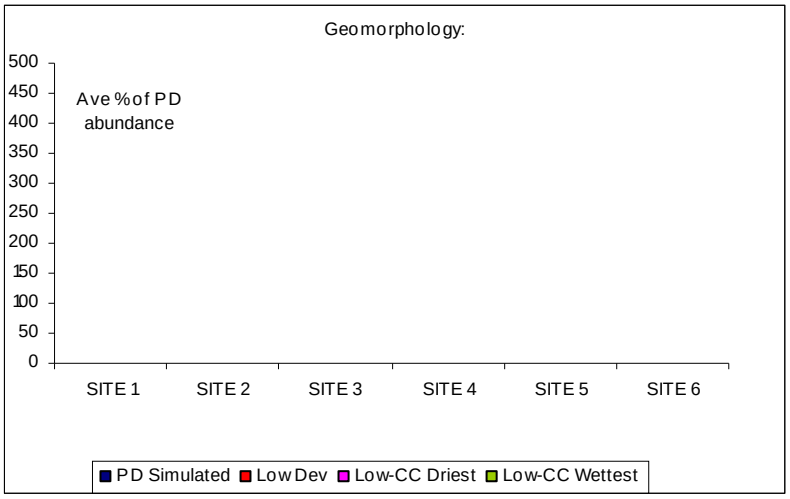


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Sediment (fine sand) is moved as bedload and not in suspension. The rate of flow is proportional to (approximately) the mean flow velocity cubed. The relationship is such that a small decrease in flow velocity results in a large decrease in sediment discharge. Since flow rate is related to flow velocity, as flow rate decreases so sediment discharge will also decrease.



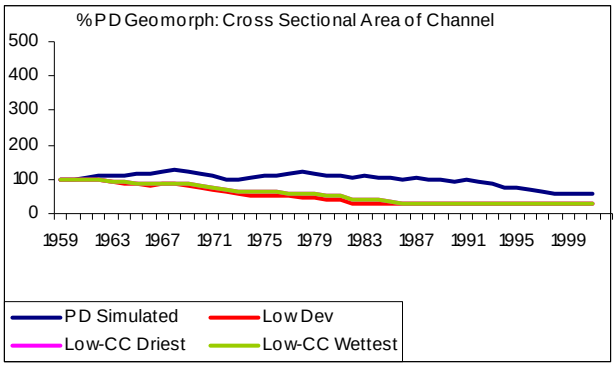
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

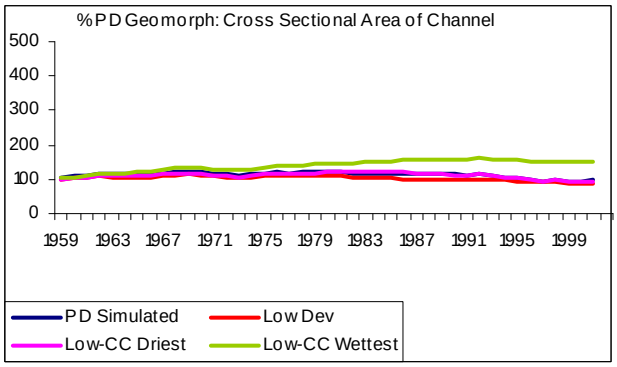
3.1.3 Cross sectional area of channel

(Cross Sectional Area of Bank Full Channel.)- This refers to the well defined channel on aerial photos, which carries the bulk of the flood. It is the perennial channel in present day conditions

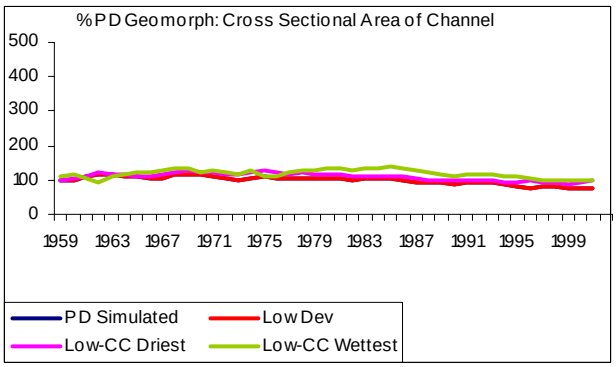
Site 1: Cubango River @ Capico



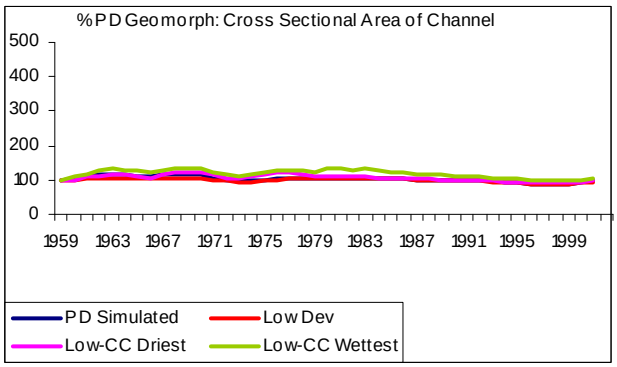
Site 2: Cubango River @ Mucundi



Site 3: Cuito River @ Cuito Cuanavale



Site 4: Okavango River @ Rundu



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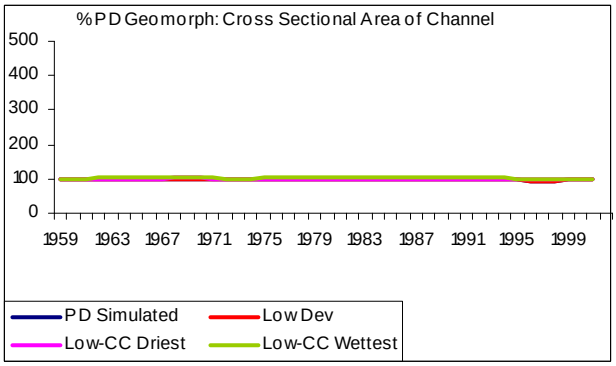
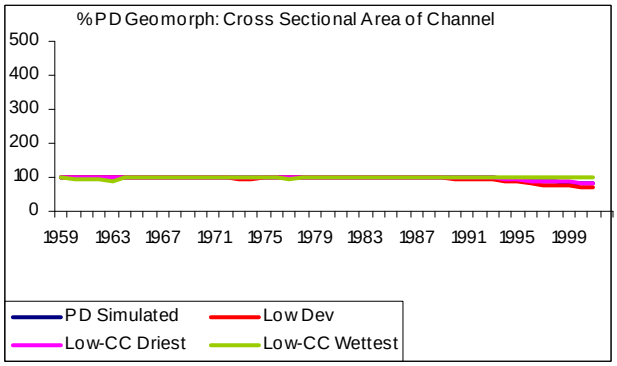
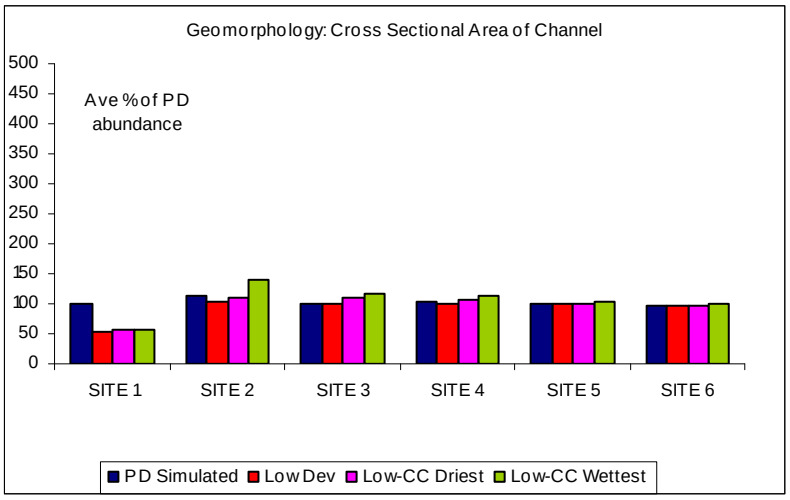


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Channel cross section responds mainly to flood conditions. Floods larger than the historical maximum should rapidly enlarge the cross sectional area. However, the channel also responds to low flow conditions or extended low flow conditions - which enables vegetation to encroach into the channel, trapping sediment, and ultimately reducing the channel cross section. This process is much slower than channel enlargement. However, intervening floods are expected to undo this trend.



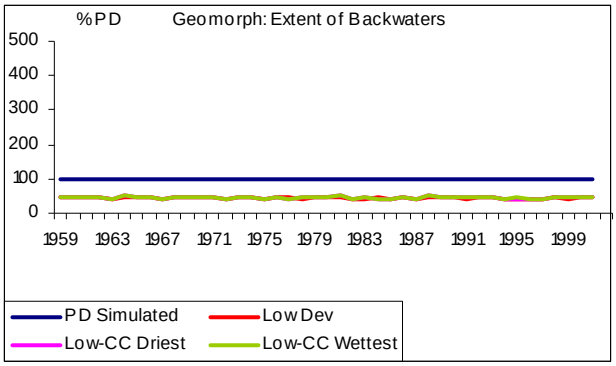
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

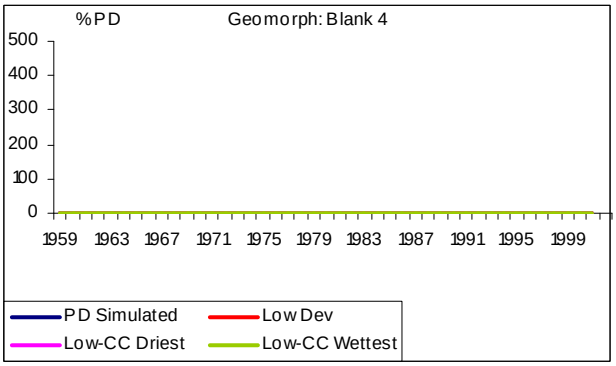
3.1.4 Extent of backwaters

(Extent of (Slow/No Flow) Backwater Areas) - Backwaters are remnants of obsolete channels, which are still connected to the main channel. During the low flow they will fill by water backing up from the river, but during flooding they may also receive water that flows over the floodplain.

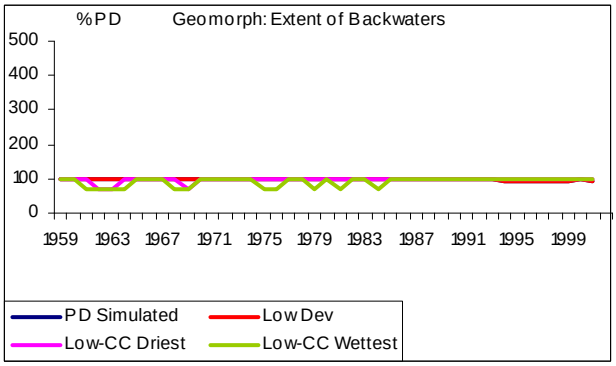
Site 1: Cubango River @ Capico



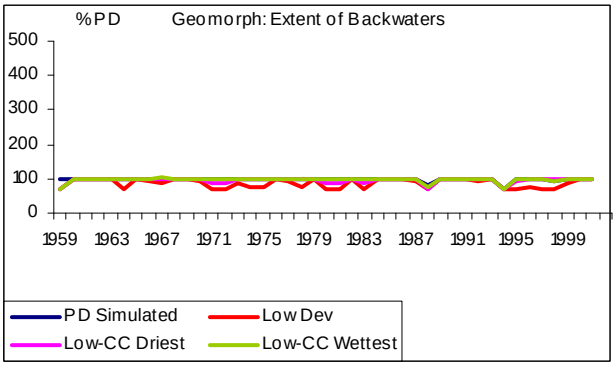
Site 2: Cubango River @ Mucundi



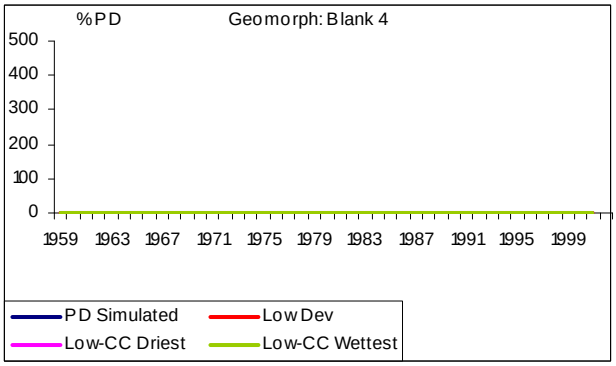
Site 3: Cuito River @ Cuito Cuanavale



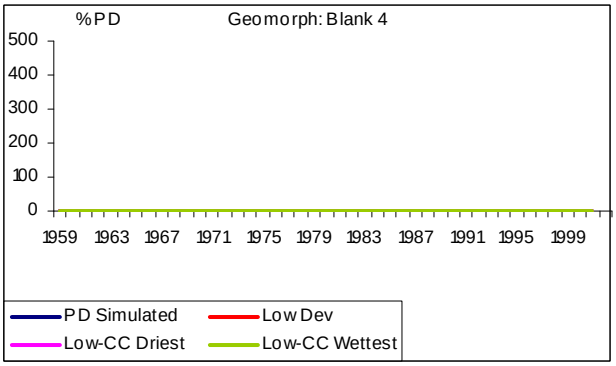
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

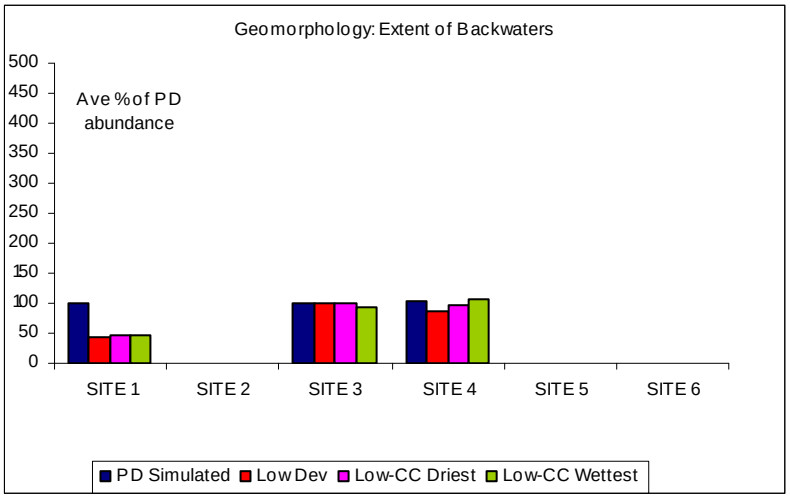


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Filling or emptying of backwaters is directly related to the water level in the river. Backwaters gradually fill with sediment and therefore may be shallower than the main channel - in that case they may empty before the river dries up. The backwaters tend to be steep sided, so the surface area changes little as water depth changes.



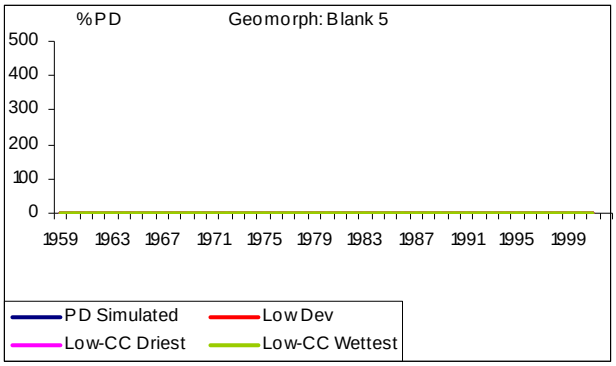
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

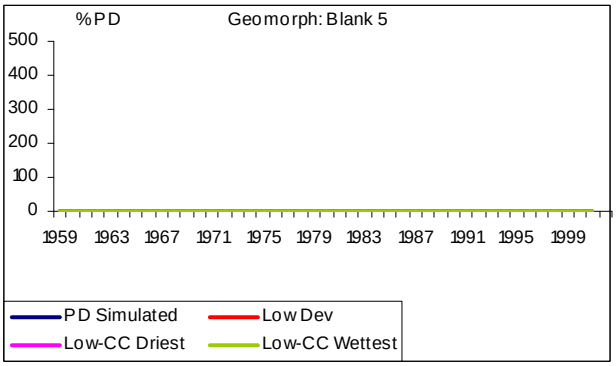
3.1.5 Sand bars at low flow

(Extent of Exposed Sand Bars at Low Flow)- Extensive exposed sand bars exist mainly below the falls. Upriver the sand bars are mostly submerged just below the surface during the low flow season.

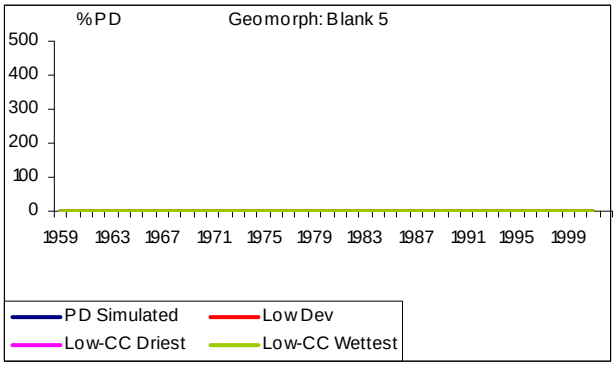
Site 1: Cubango River @ Capico



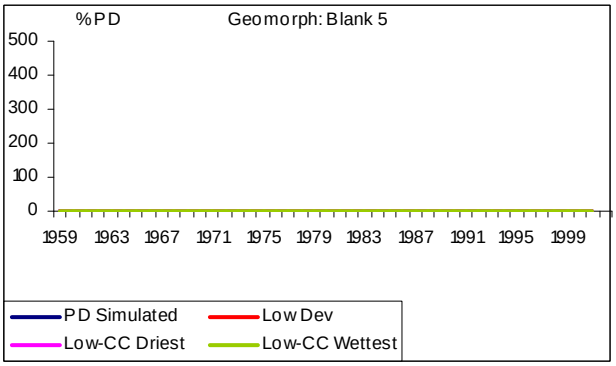
Site 2: Cubango River @ Mucundi



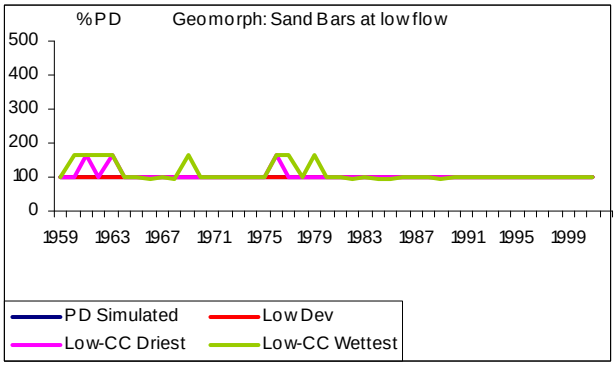
Site 3: Cuito River @ Cuito Cuanavale



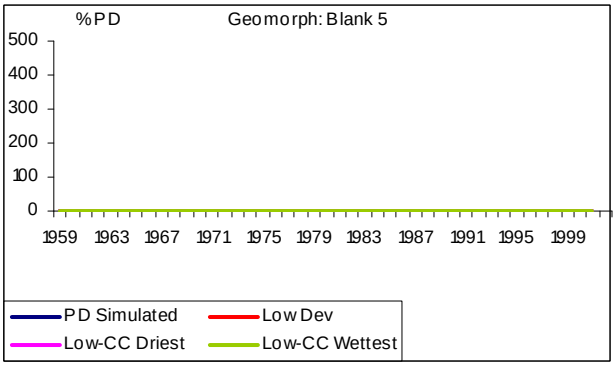
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

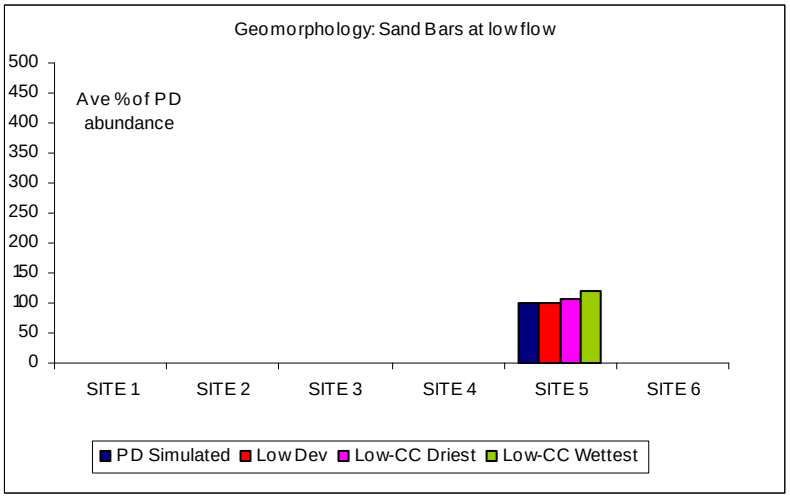


Site 6: Okavango River @ Pan Handle



Summary change per scenario

If one considers only the effect of water flow on sandbanks, then lower flow will expose a greater extent of sandbanks. However, the real issue here is not water but the fact that dams and weirs trap sediment. Downstream of a weir or dam the river is deprived of sediment, so it erodes its bed, banks and floodplains until it is once again carrying its maximum load. Thus, for some distance downstream of a weir or dam the sandbanks will be removed.



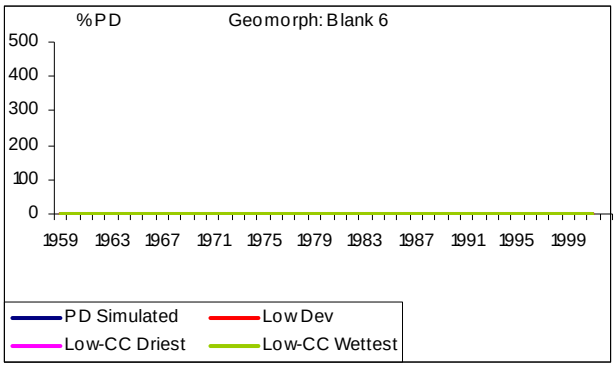
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

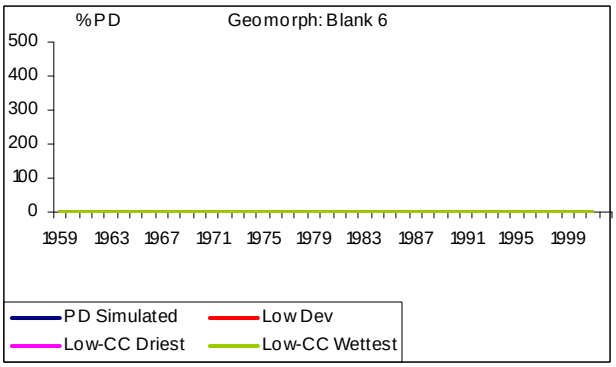
3.1.6 Extent of vegetated islands

(Extent of vegetated islands)- Vegetated islands in the Mukwe-Andara-Popa Falls section of the river (and upstream) are normally comprised of sand on bedrock. Grass, reeds, bush and trees stabilise the sand by reducing wash away during above-average high flows and also promoting deposition of more sand during overtopping of the island.

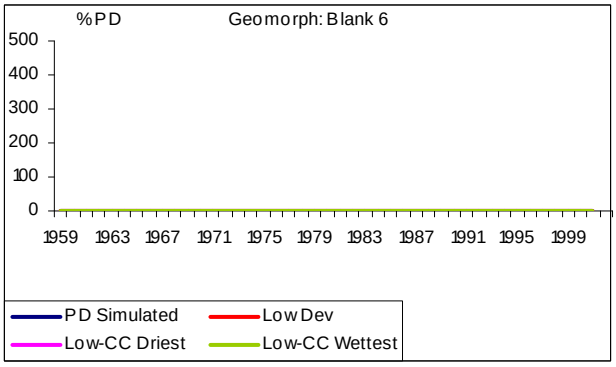
Site 1: Cubango River @ Capico



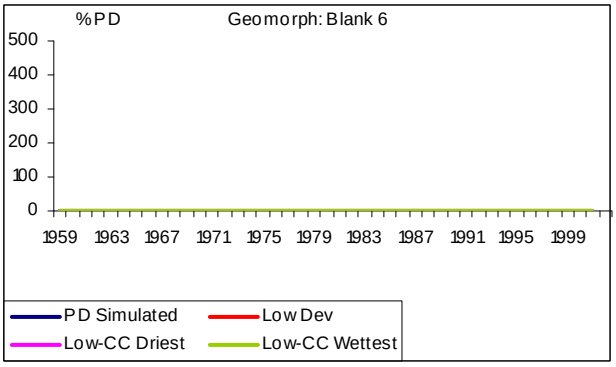
Site 2: Cubango River @ Mucundi



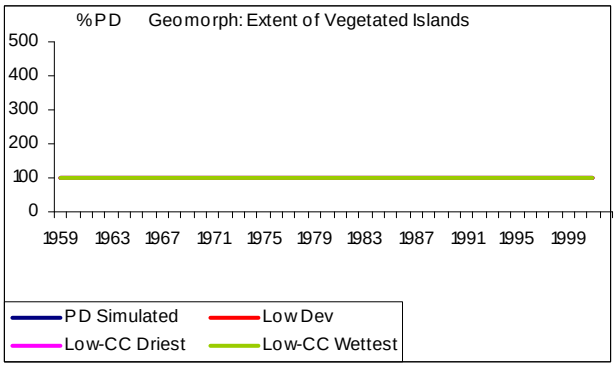
Site 3: Cuito River @ Cuito Cuanavale



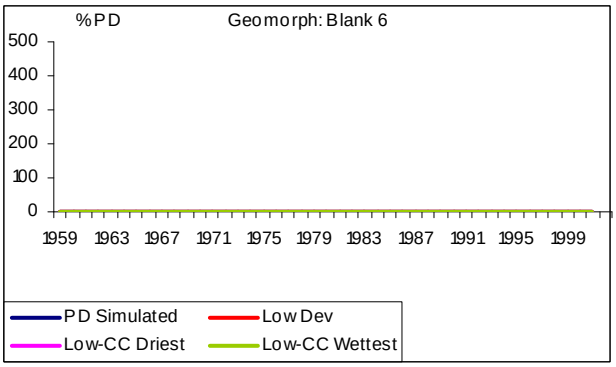
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

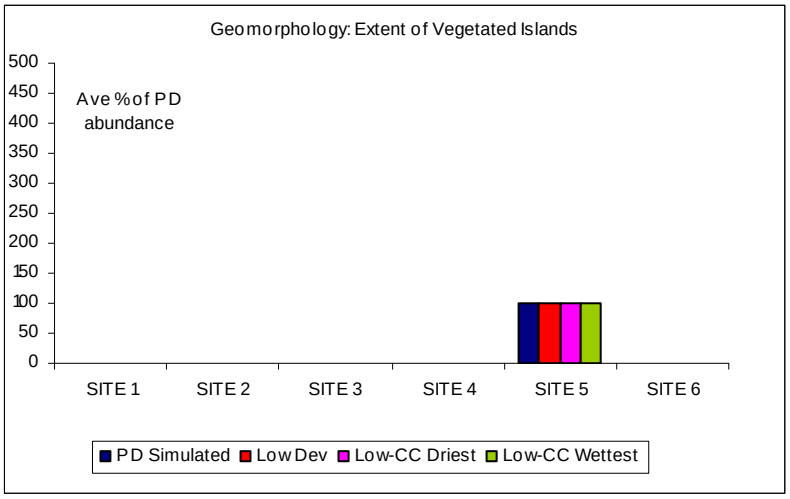


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Reduced flows have little impact on vegetated islands as long as the plants there still get enough water to survive and regenerate themselves. Excessively high floods, however, are likely to cause erosion of the margins of islands. In many cases this erosion is limited to the margins because of the bedrock base to the island.



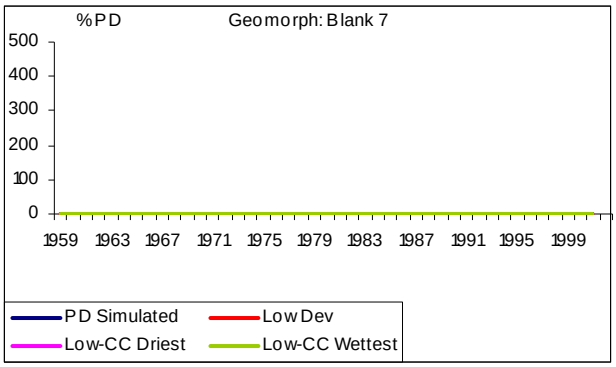
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

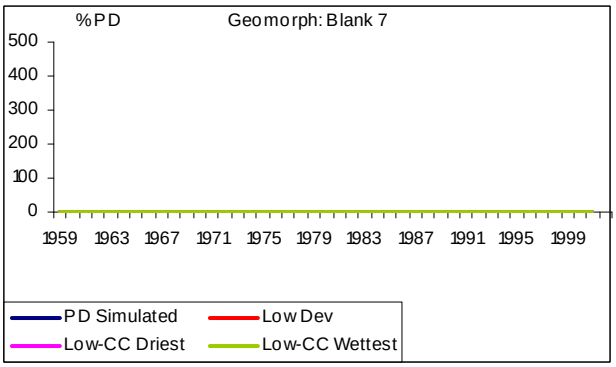
3.1.7 Percentage clays on floodplain

(Percentage Silt and Clays in the top 300mm of the floodplain)- Floodplains are made predominantly of fine sand, but there is a small amount of silt and clay-sized particles, which are also deposited by the river. The silt and clay is significant for agriculture because it helps to retain moisture and nutrients.

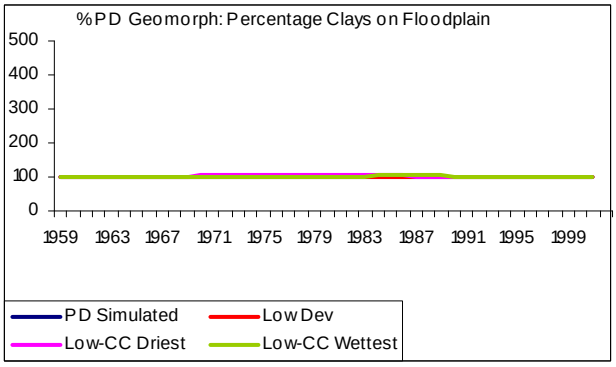
Site 1: Cubango River @ Capico



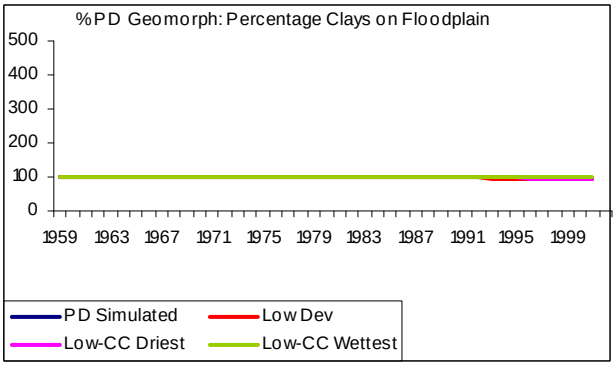
Site 2: Cubango River @ Mucundi



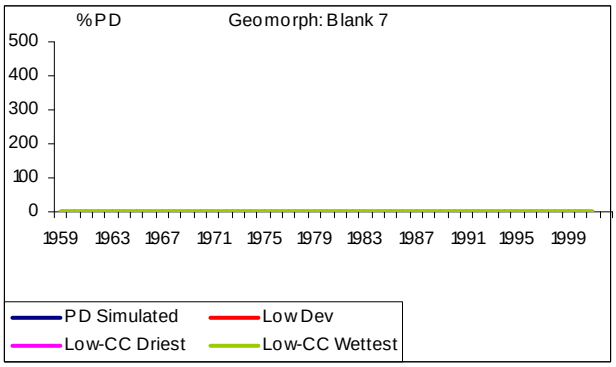
Site 3: Cuito River @ Cuito Cuanavale



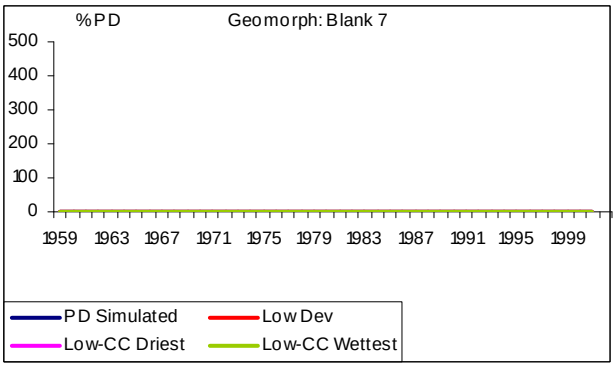
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

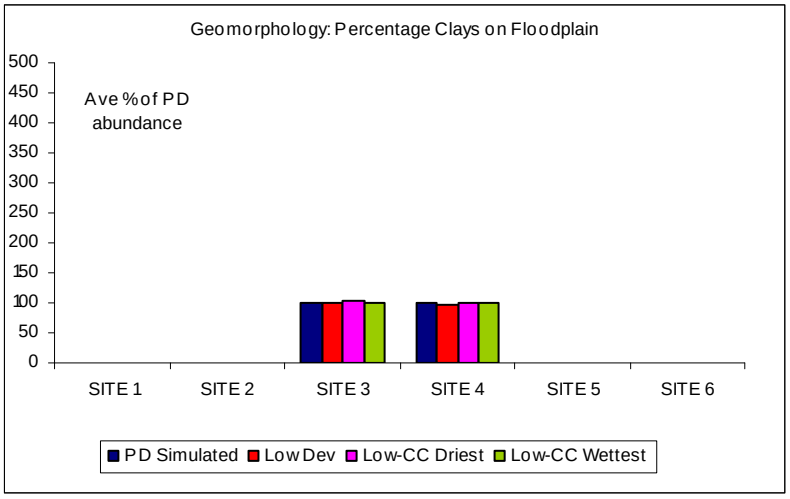


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Silt and clay tend to get lost due to downward mixing by soil organisms, trampling by livestock, and removal by wind. However, these fine particles are replenished by flooding.



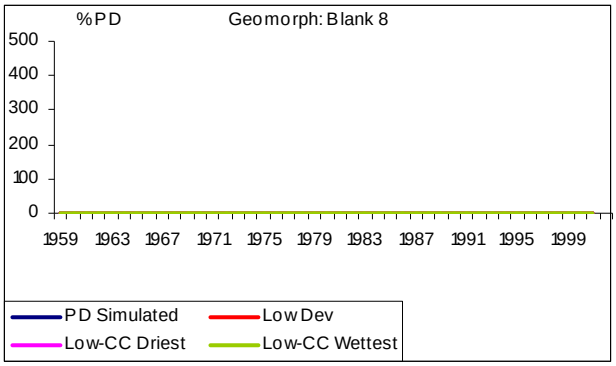
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

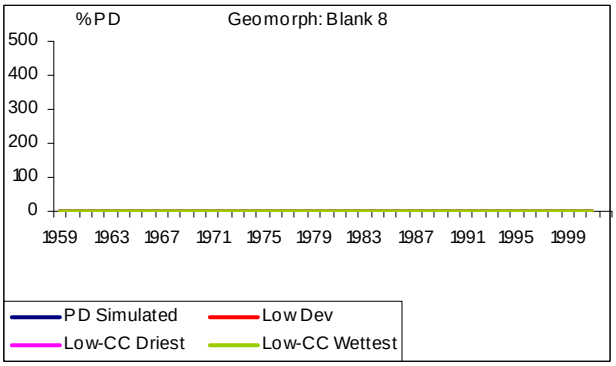
3.1.8 Extent of inundated floodplain

(Extent of the floodplain flooded each wet season)- Reduced volume of flow in the flood season will result in less overbank flooding. This results in smaller areas of the floodplain being inundated.

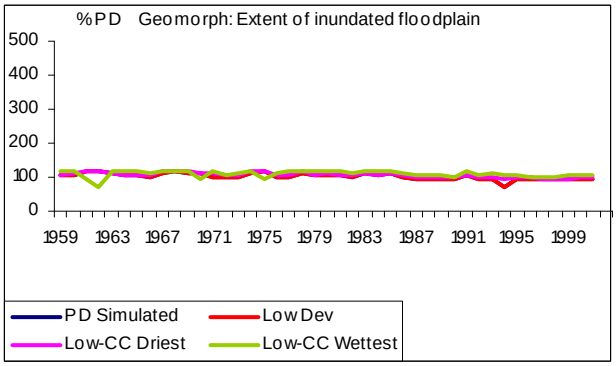
Site 1: Cubango River @ Capico



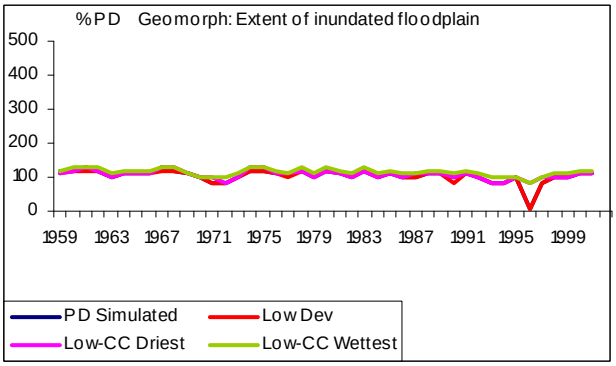
Site 2: Cubango River @ Mucundi



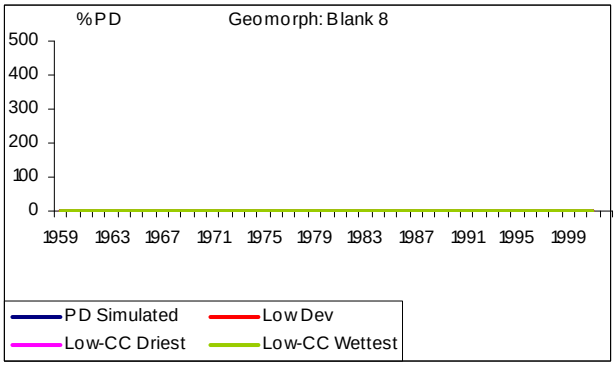
Site 3: Cuito River @ Cuito Cuanavale



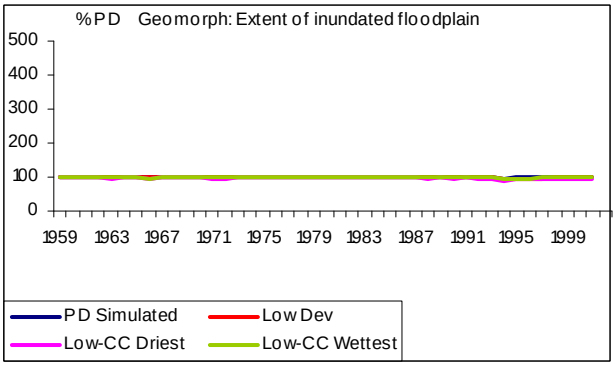
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

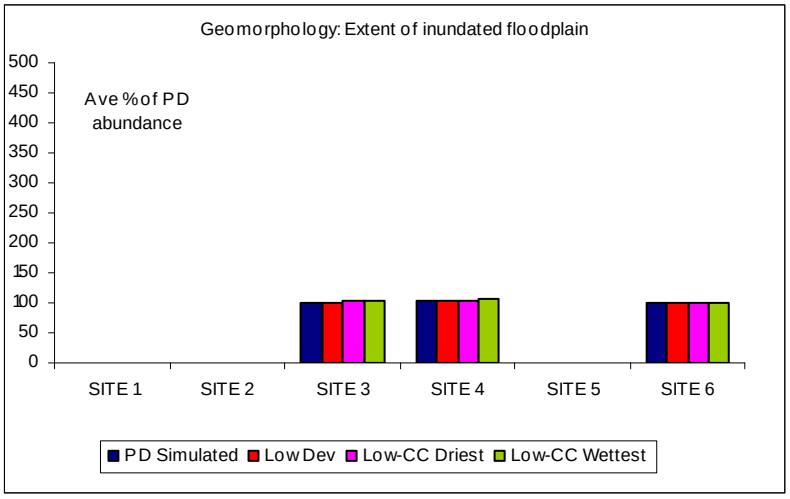


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Reduced volume of flow in the flood season will result in less overbank flooding. This results in smaller areas of the floodplain being inundated.



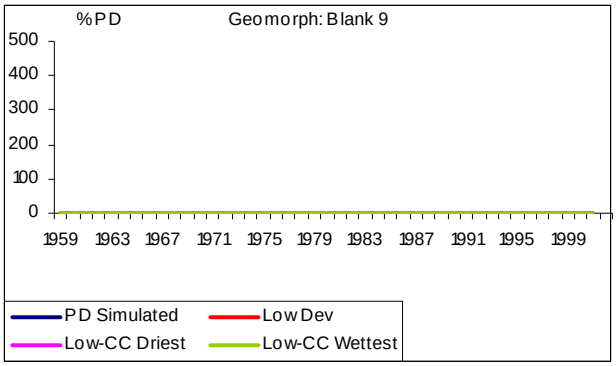
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

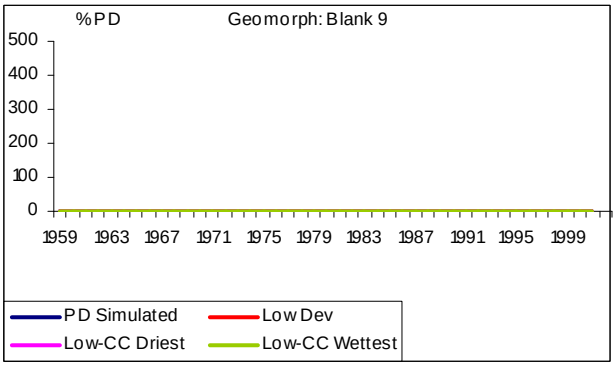
3.1.9 Inundated pools and pans

(Extent of inundated pools/pans on floodplain at the end of the dry season) - Pools that remain on the floodplain at the end of the dry season are assumed to be fed by groundwater movement from the river channel.

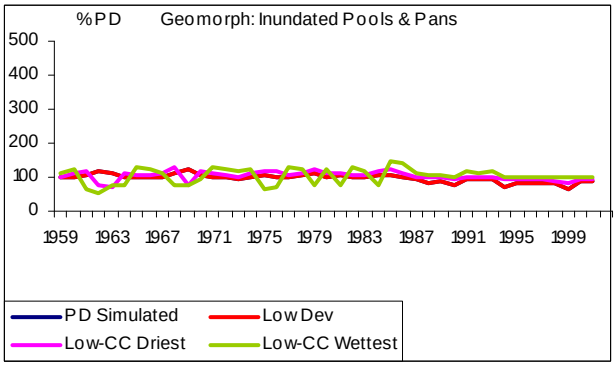
Site 1: Cubango River @ Capico



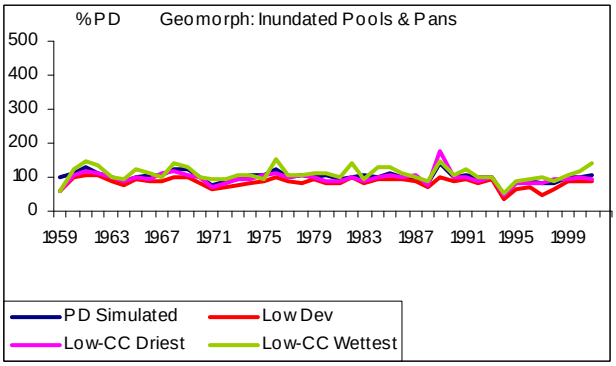
Site 2: Cubango River @ Mucundi



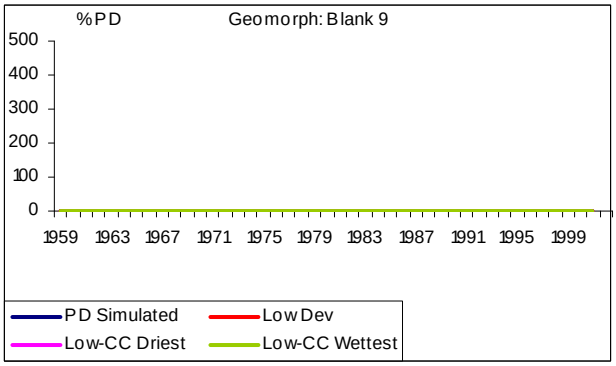
Site 3: Cuito River @ Cuito Cuanavale



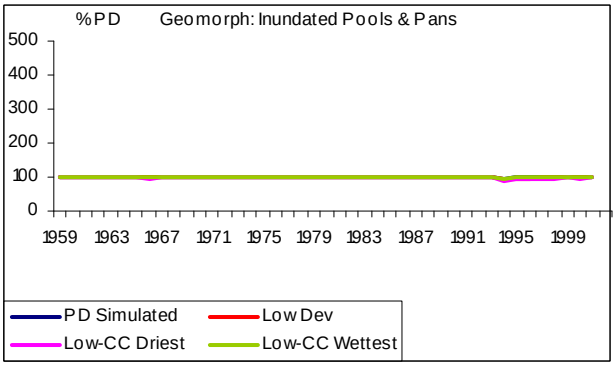
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

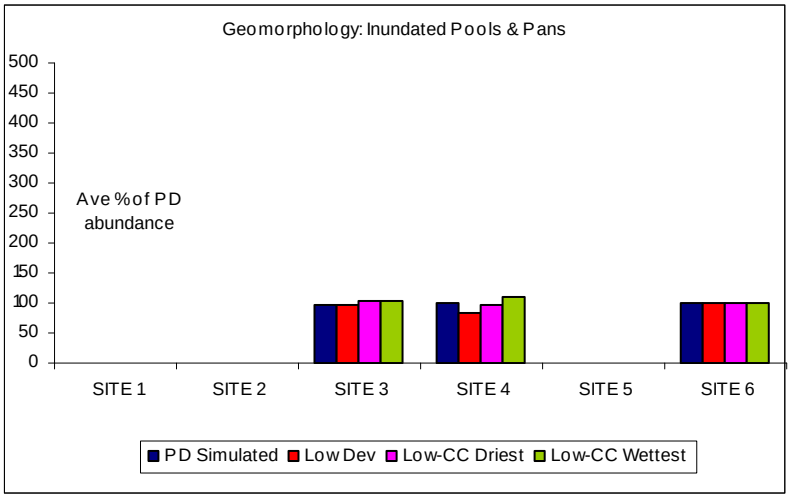


Site 6: Okavango River @ Pan Handle



Summary change per scenario

As the river level drops, so the water table in the floodplain will also drop. If the bed of a pool no longer intersects the water table, the pool will dry out. (Seepage into the pool from the non-saturated zone may also contribute to pool water.) Although high flows play a role by replenishing groundwater in floodplains, we assume that perennial pools at the end of the dry season are maintained by groundwater.



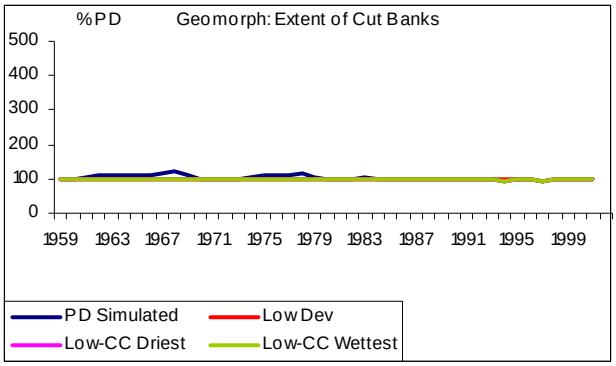
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

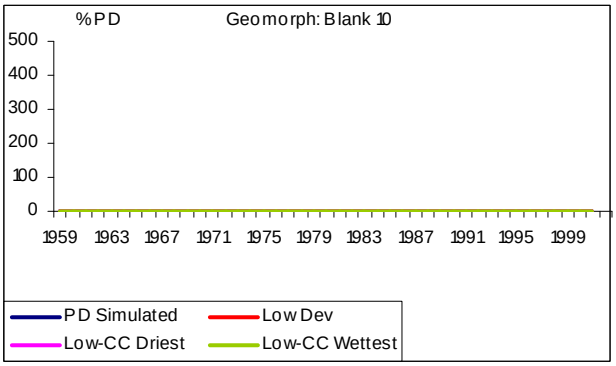
3.1.10 Extent of cut banks

(Extent of cut banks along the active channel) - Cut banks are a function mainly of high flow periods, but they are also affected when river flow drops rapidly - in that case bank collapse tends to occur.

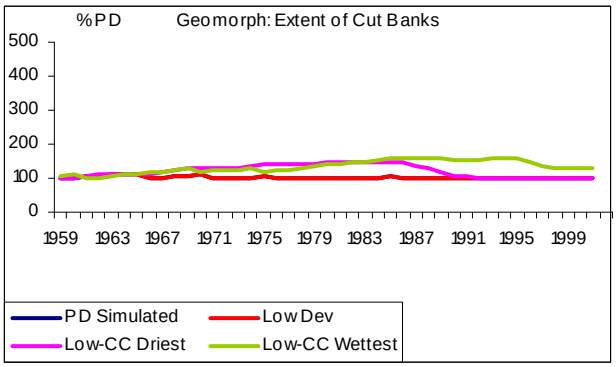
Site 1: Cubango River @ Capico



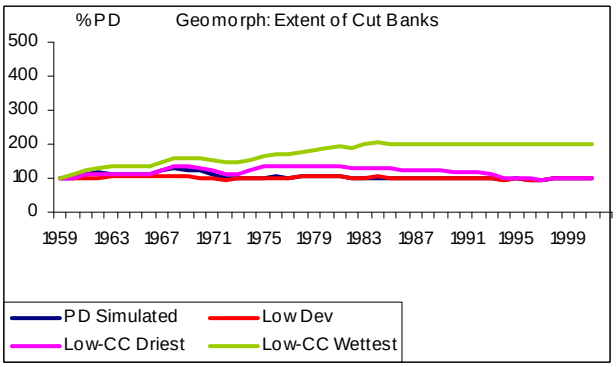
Site 2: Cubango River @ Mucundi



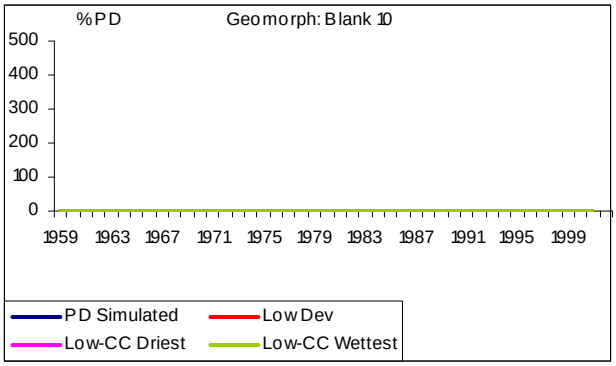
Site 3: Cuito River @ Cuito Cuanavale



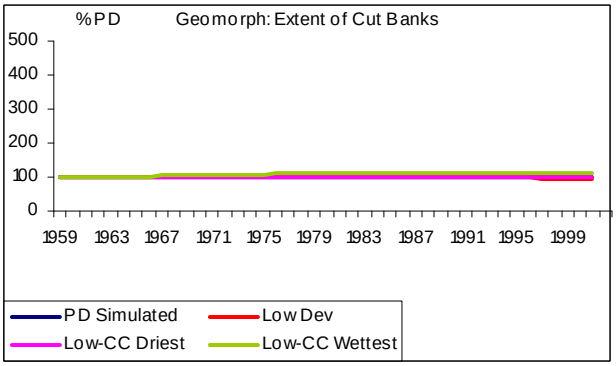
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

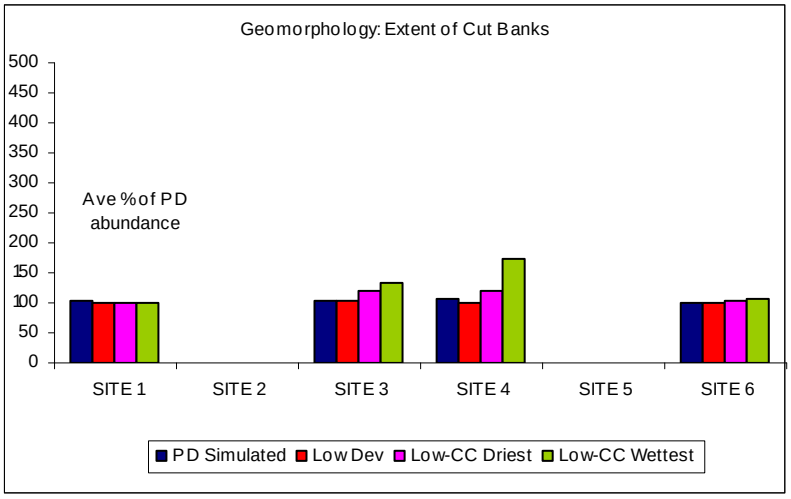


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Higher flow velocities during flooding will erode the banks. When the water level drops rapidly, then hydrostatic pressure of water in the sandy bank material tends to result in bank collapse.

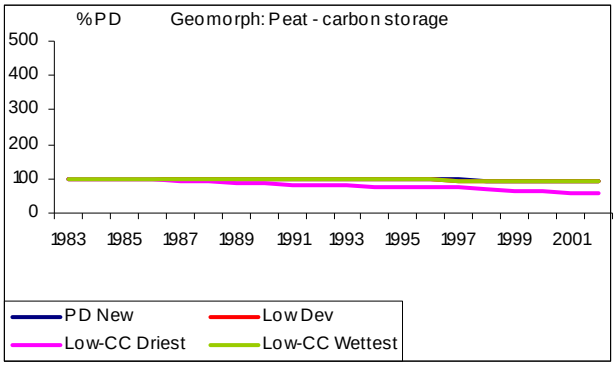


References

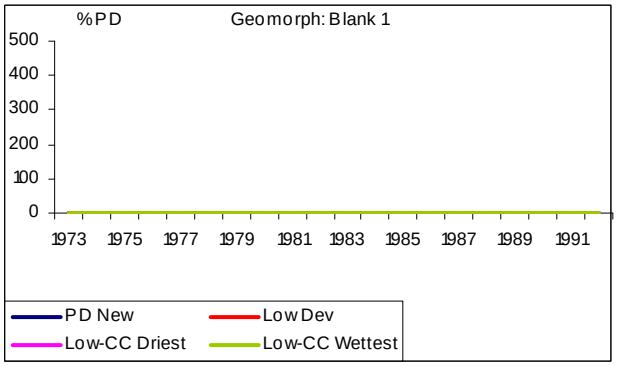
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.1.11 Peat - carbon storage

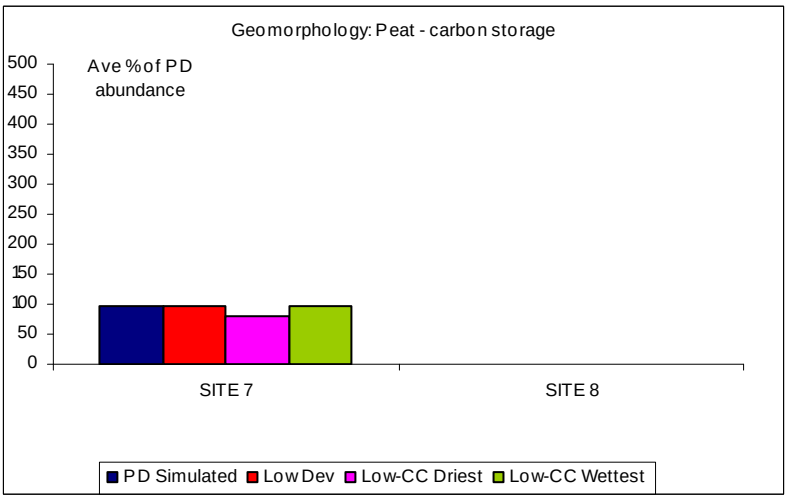
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.2. Water Quality

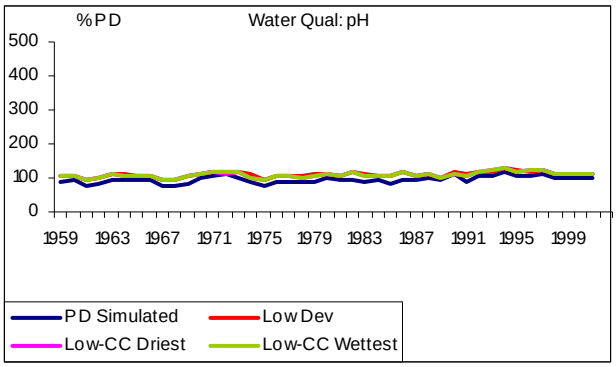
This section provides the time-series for water quality indicators under the flow regime resulting from the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- pH
- Conductivity
- Temperature
- Turbidity
- Dissolved oxygen
- Total nitrogen
- Total phosphorus
- Chlorophyll a.

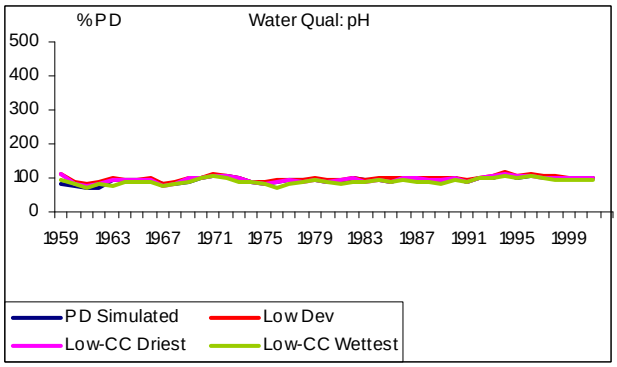
3.2.1 pH

(In channel)- Unitless

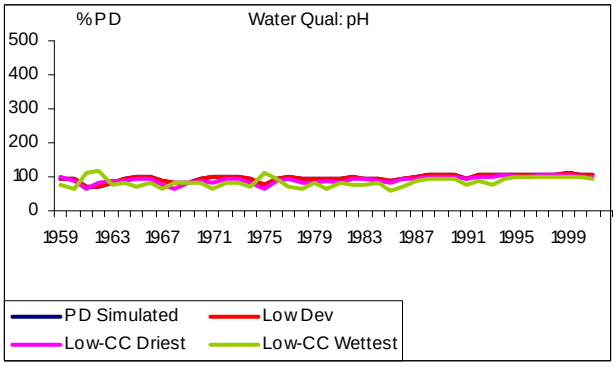
Site 1: Cubango River @ Capico



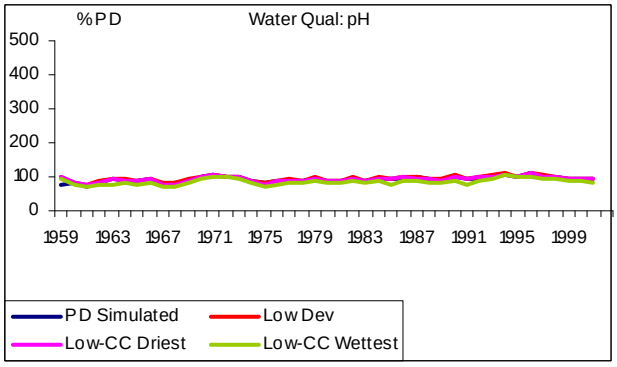
Site 2: Cubango River @ Mucundi



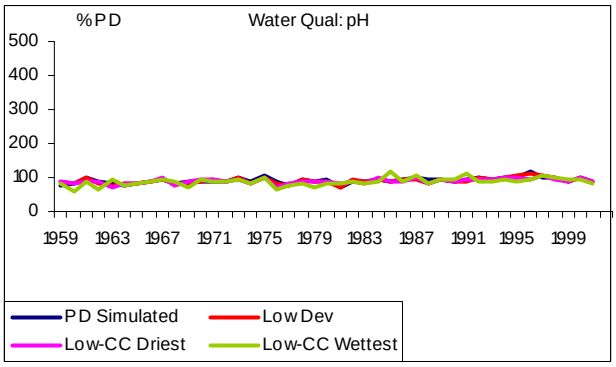
Site 3: Cuito River @ Cuito Cuanavale



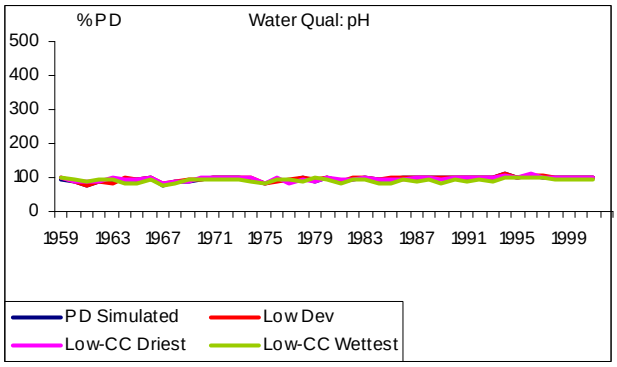
Site 4: Okavango River @ Rundu



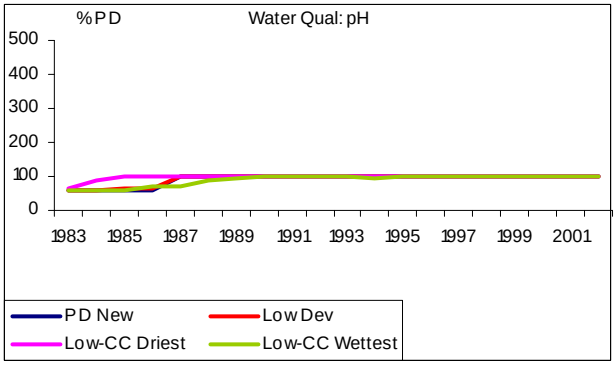
Site 5: Okavango River @ Popa Falls



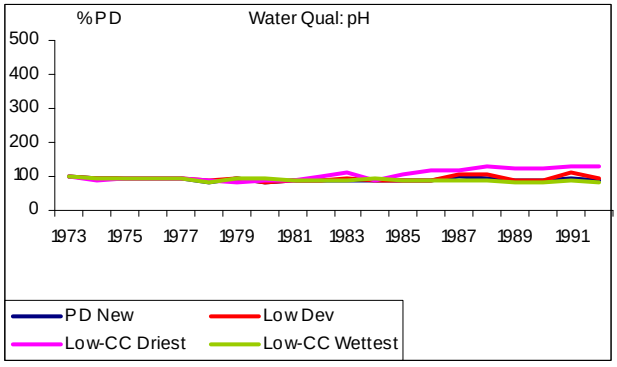
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

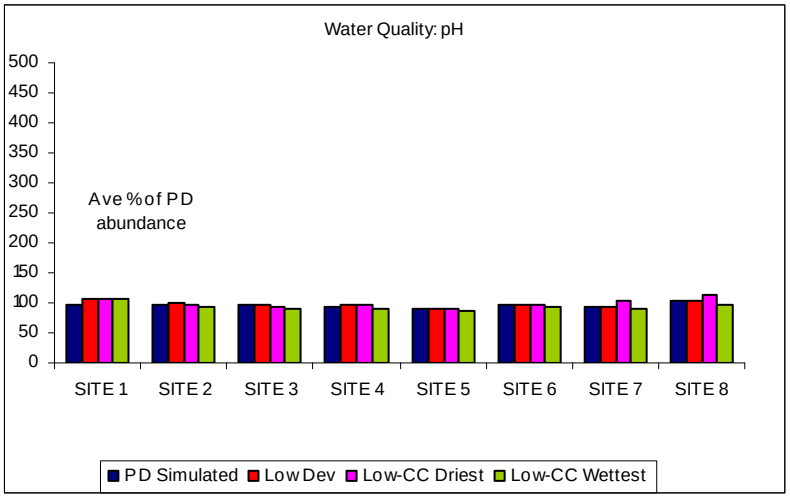


Site 8: Boteti River



Summary change per scenario

Generally increasing with decreasing flow. In the simulated Present Day, values range between 34% and 268% of the PD median, increasing in drier years of lower flow.



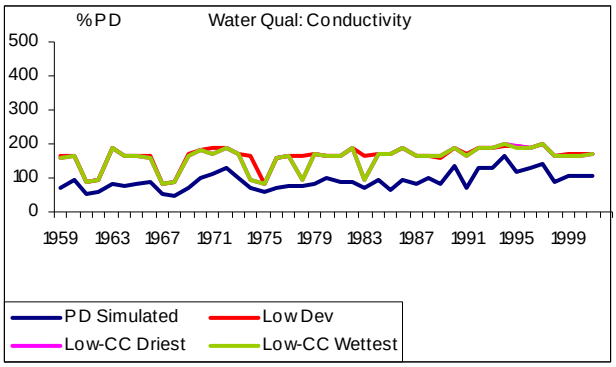
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

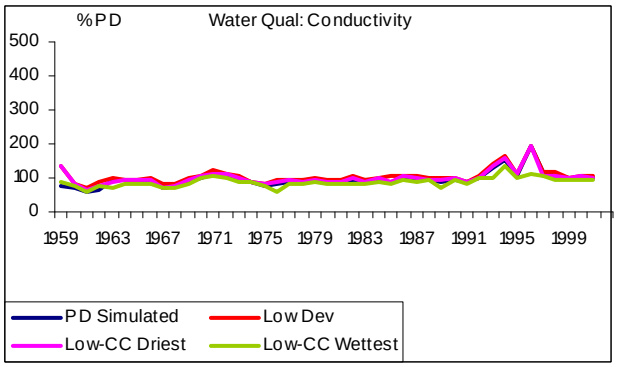
3.2.2 Conductivity

(In channel)- us/cm

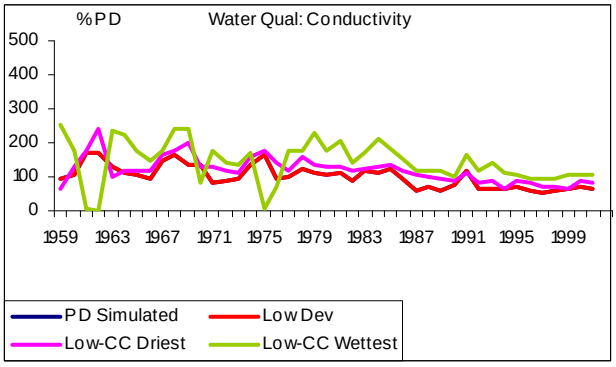
Site 1: Cubango River @ Capico



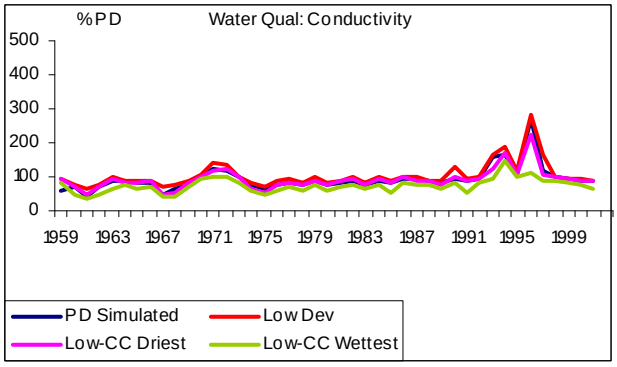
Site 2: Cubango River @ Mucundi



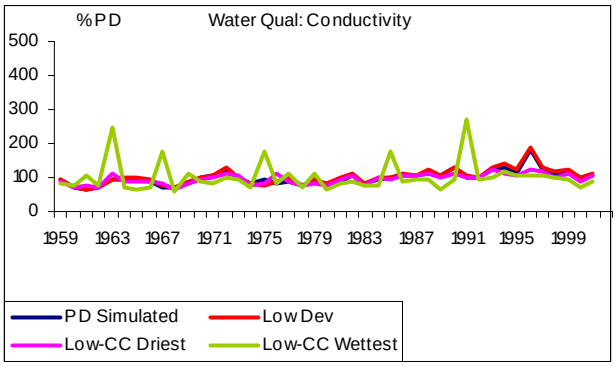
Site 3: Cuito River @ Cuito Cuanavale



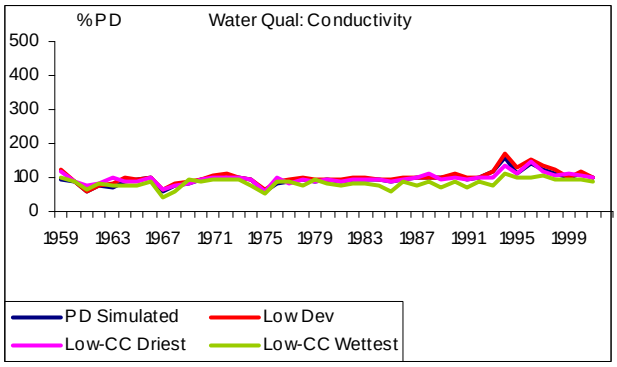
Site 4: Okavango River @ Rundu



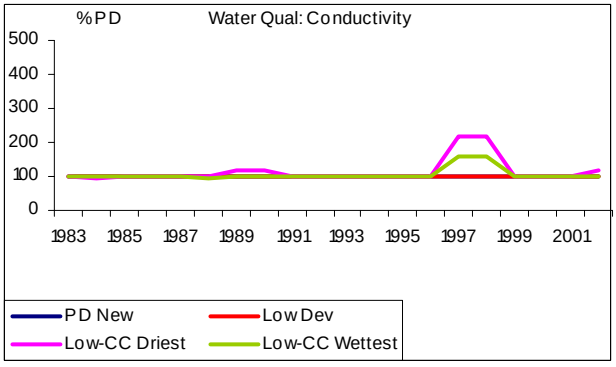
Site 5: Okavango River @ Popa Falls



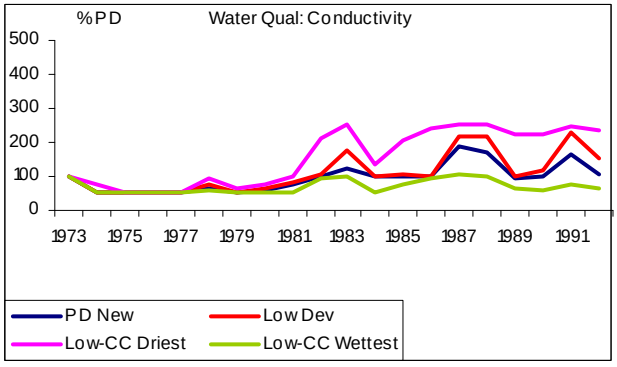
Site 6: Okavango River @ Pan Handle



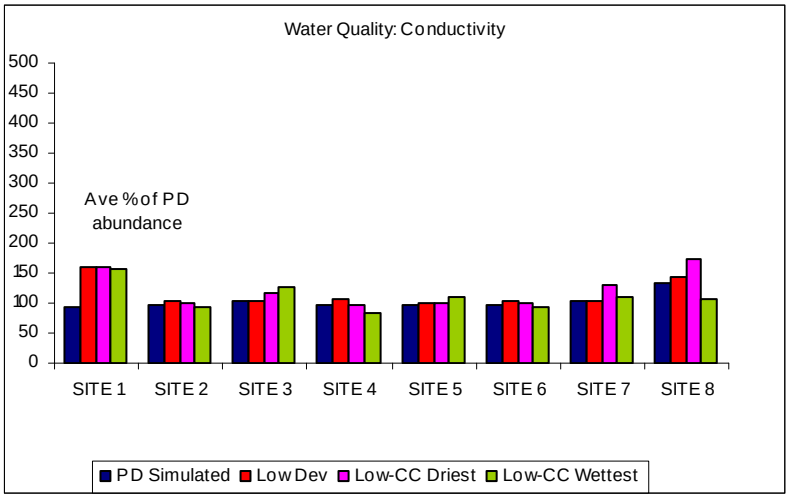
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Values decrease with increasing flow.

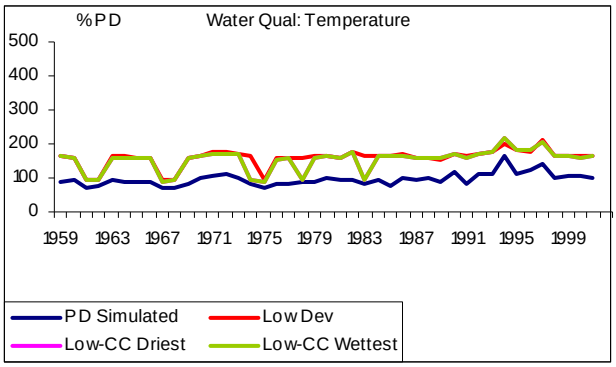


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

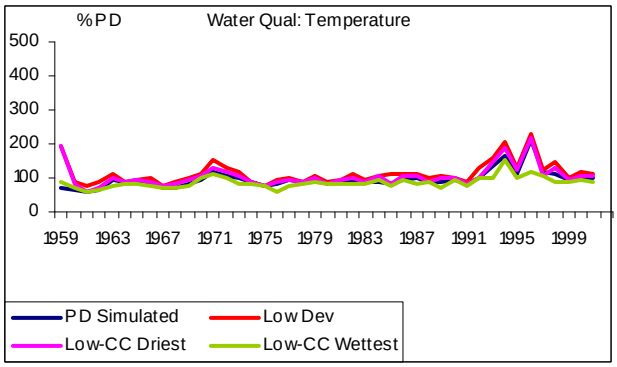
3.2.3 Temperature

(In channel)- diel range

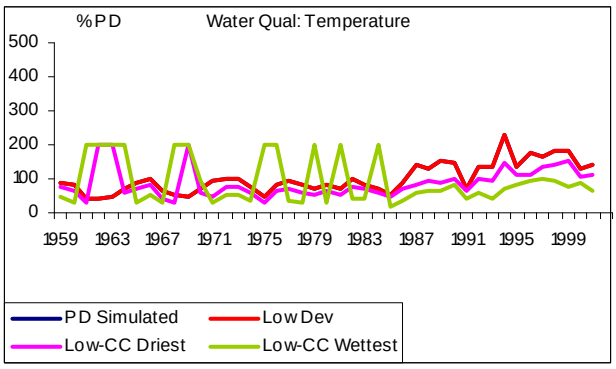
Site 1: Cubango River @ Capico



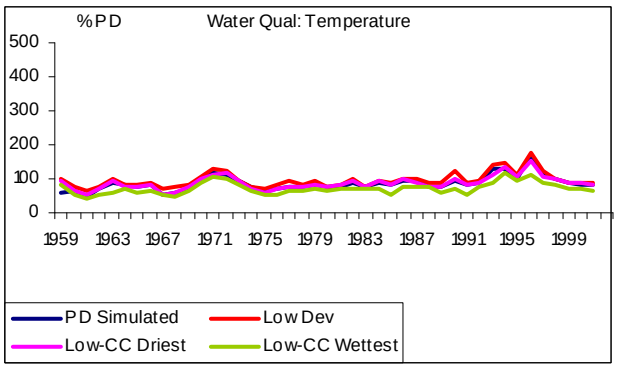
Site 2: Cubango River @ Mucundi



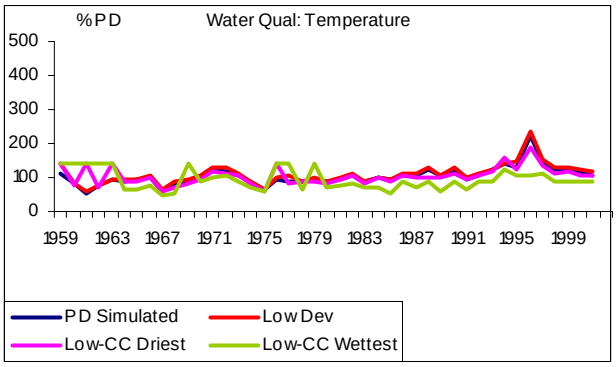
Site 3: Cuito River @ Cuito Cuanavale



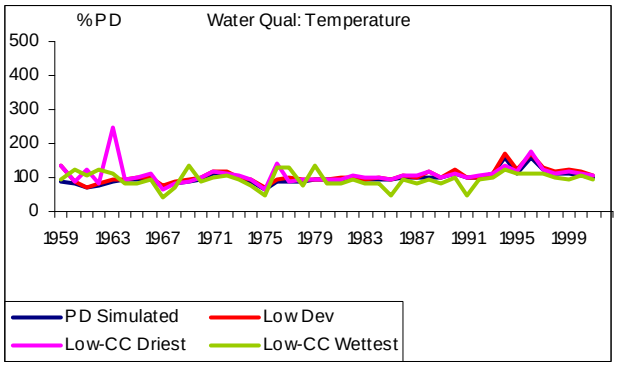
Site 4: Okavango River @ Rundu



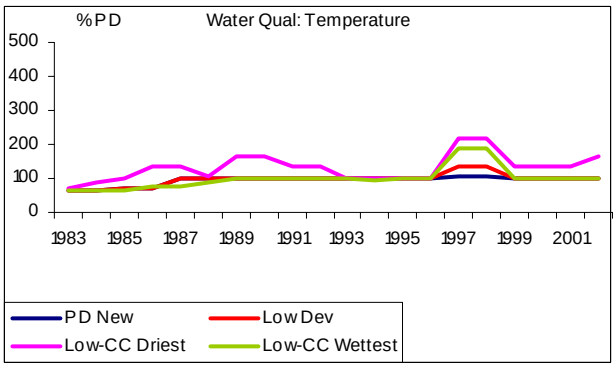
Site 5: Okavango River @ Popa Falls



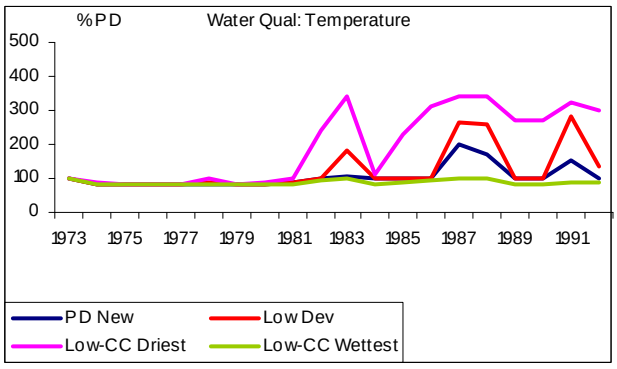
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

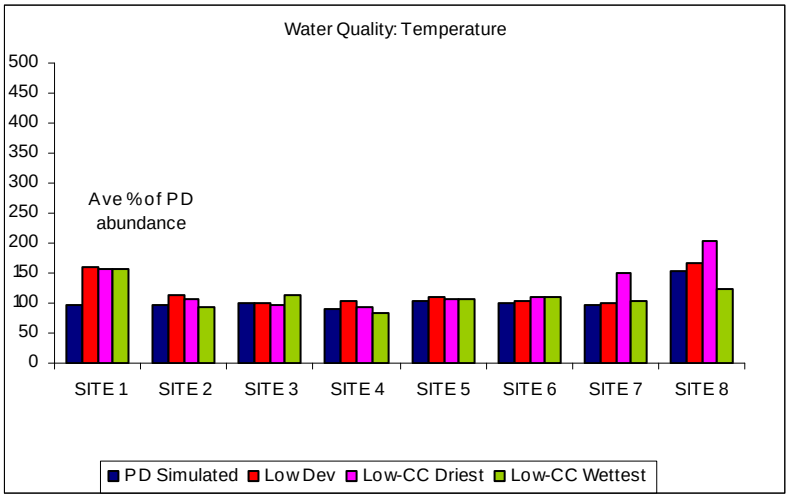


Site 8: Boteti River



Summary change per scenario

Generally the Diel Temperature Range increases with decreasing flow.



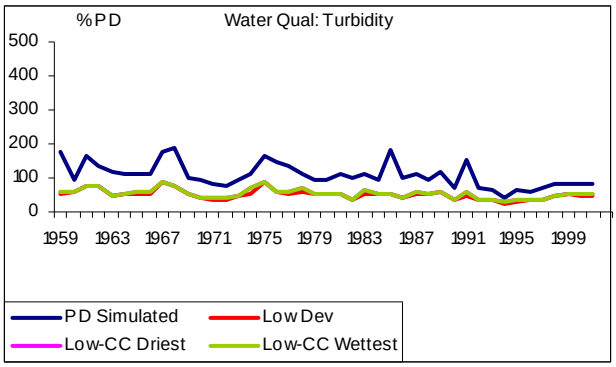
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

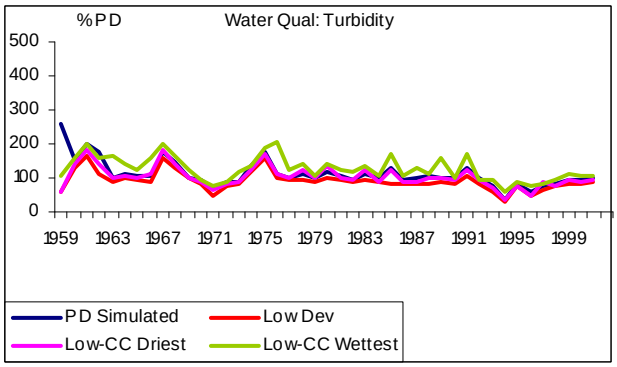
3.2.4 Turbidity

(In channel)- mg/l

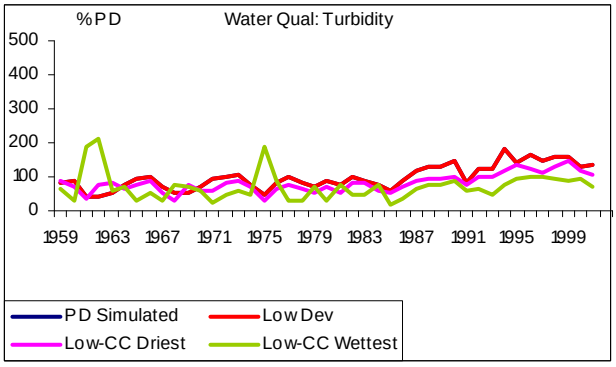
Site 1: Cubango River @ Capico



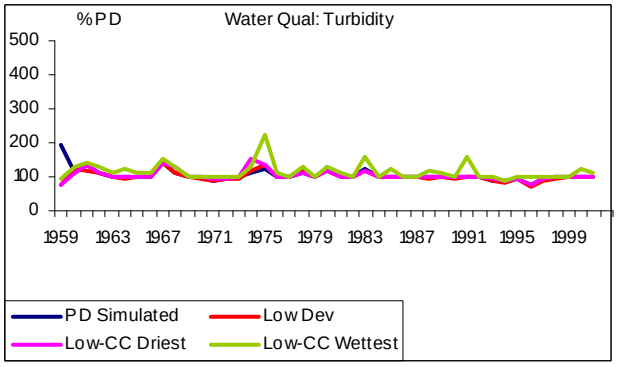
Site 2: Cubango River @ Mucundi



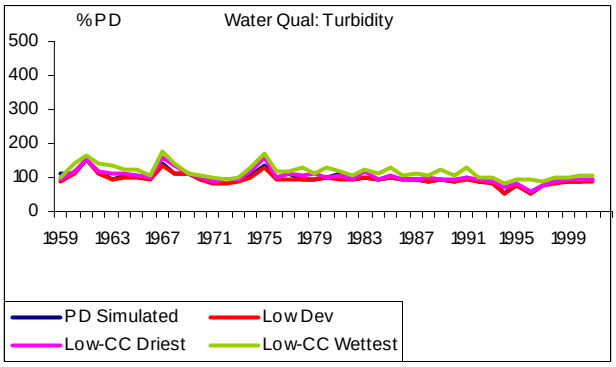
Site 3: Cuito River @ Cuito Cuanavale



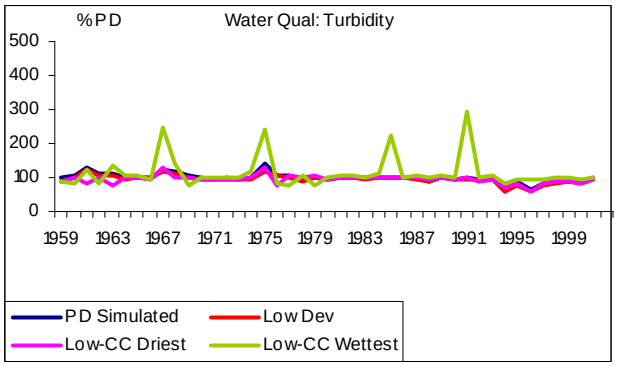
Site 4: Okavango River @ Rundu



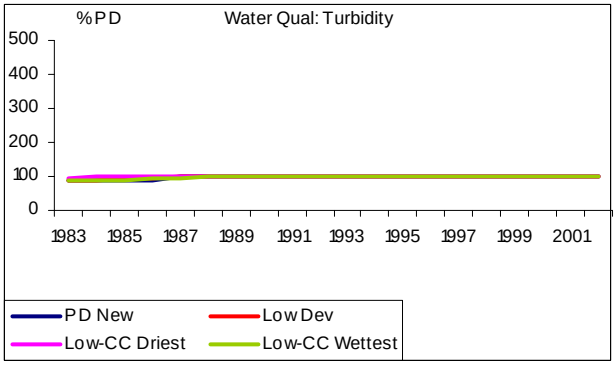
Site 5: Okavango River @ Popa Falls



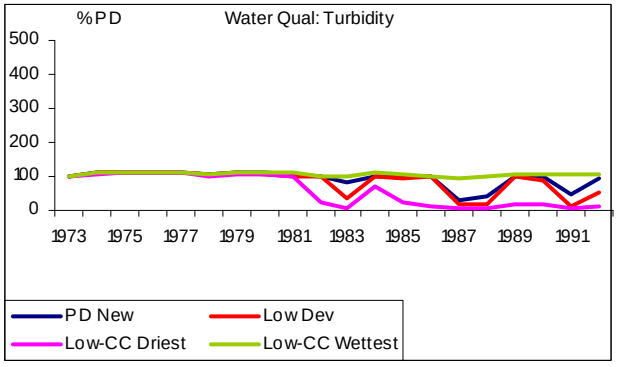
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

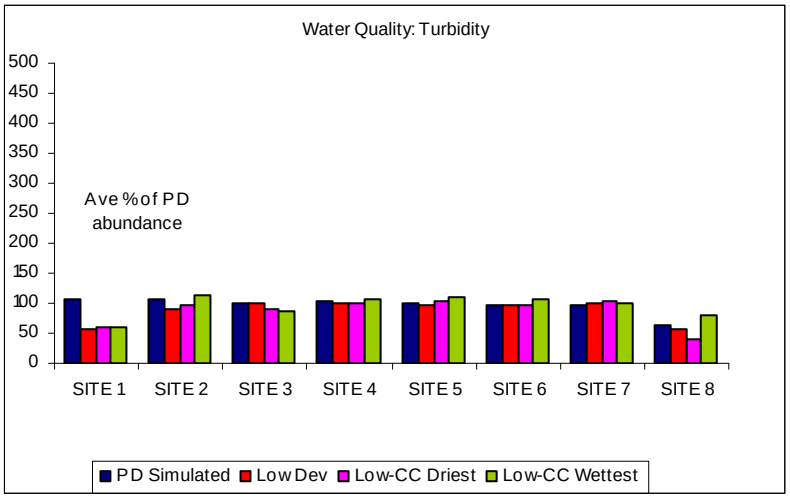


Site 8: Boteti River



Summary change per scenario

In general turbidity increases with increasing flows. The exception to this is Site 7 where turbidity decreases with increasing depth. In the case of the Boteti (Site 8), the inundated (and sometimes flowing) channels tend to have higher turbidity than the isolated pools. However when the Boteti dries up, there is 'no turbidity'.



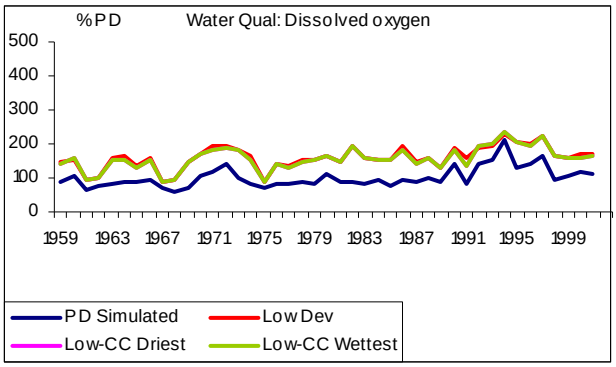
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

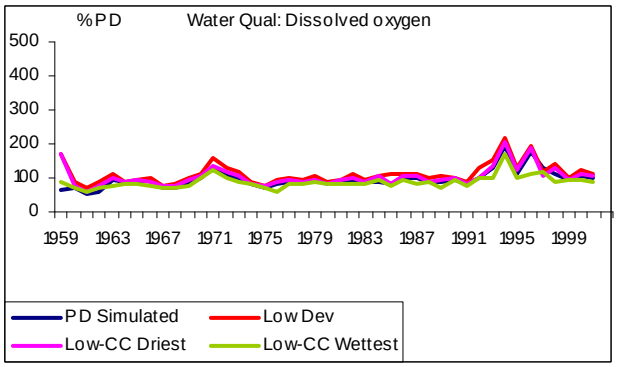
3.2.5 Dissolved oxygen

(In channel)- NTU

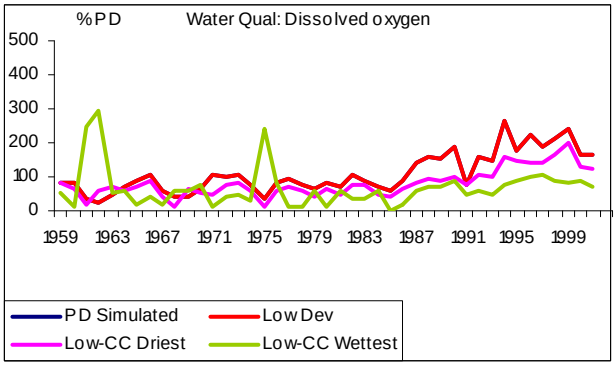
Site 1: Cubango River @ Capico



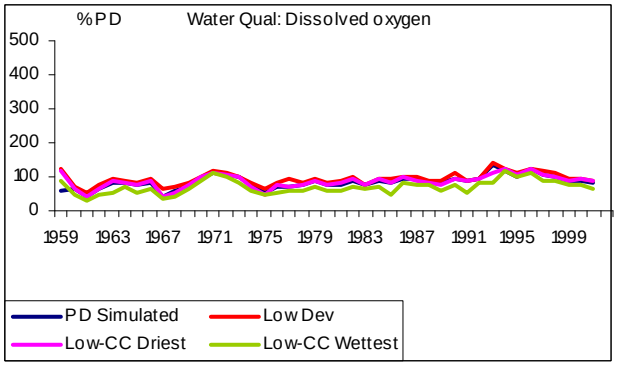
Site 2: Cubango River @ Mucundi



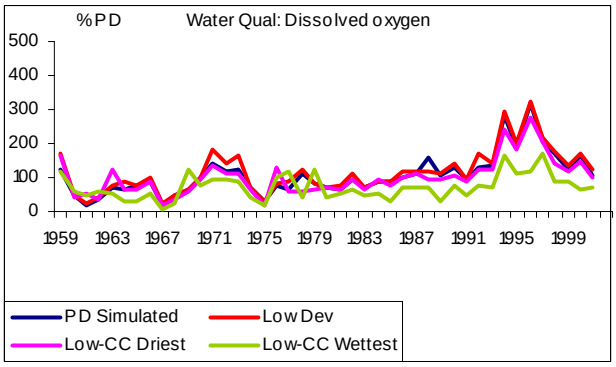
Site 3: Cuito River @ Cuito Cuanavale



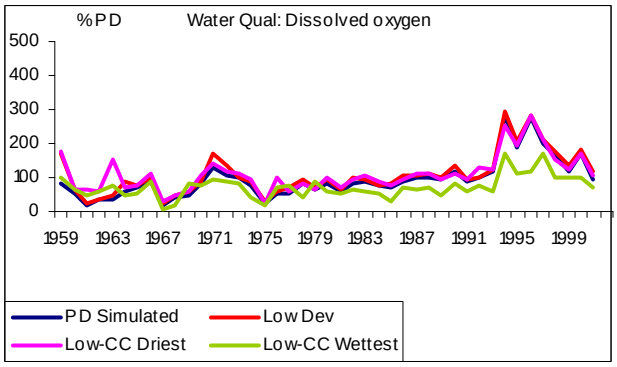
Site 4: Okavango River @ Rundu



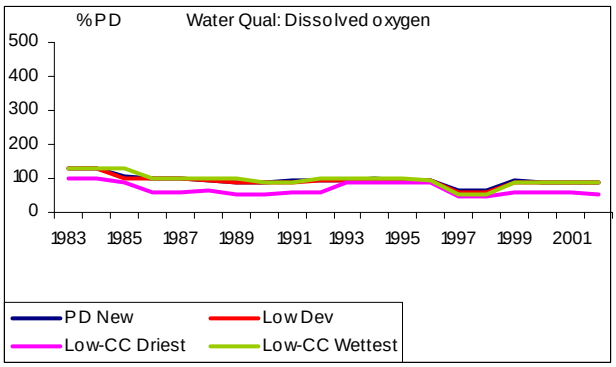
Site 5: Okavango River @ Popa Falls



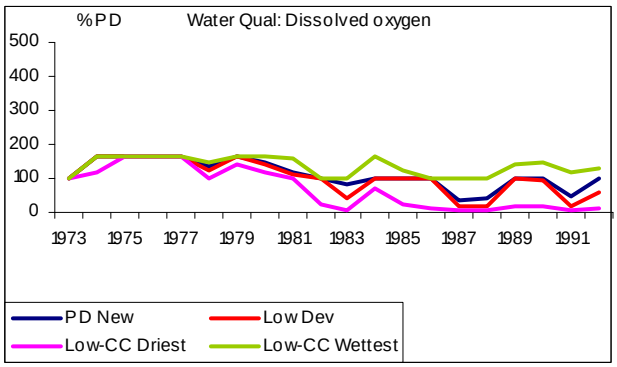
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

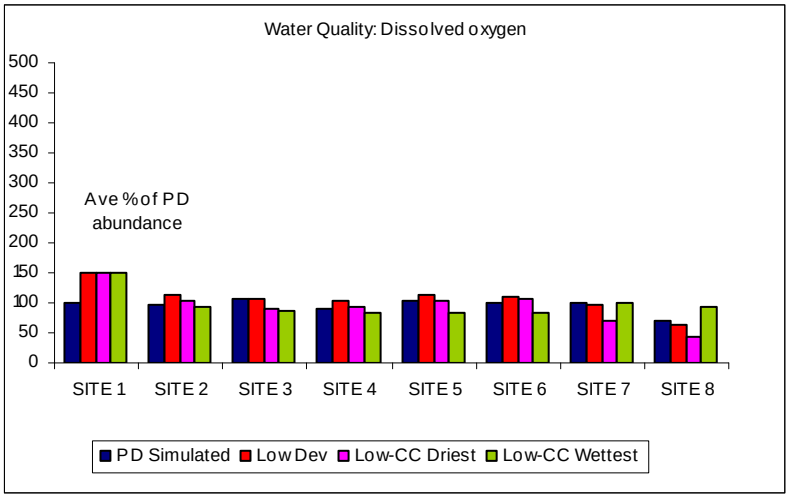


Site 8: Boteti River



Summary change per scenario

Decrease in flow results in increase in Dissolved Oxygen at sites 1 - 6. At sites 7 & 8, the concentrations decrease with decrease in flow



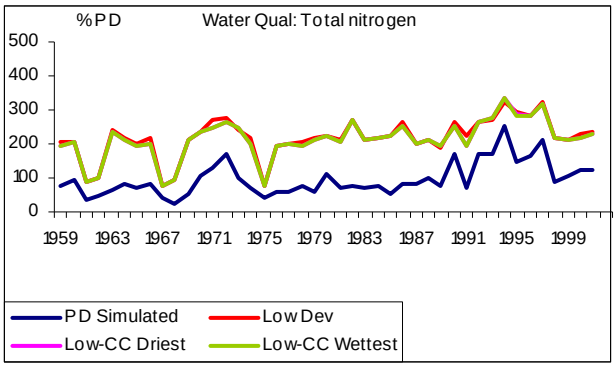
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

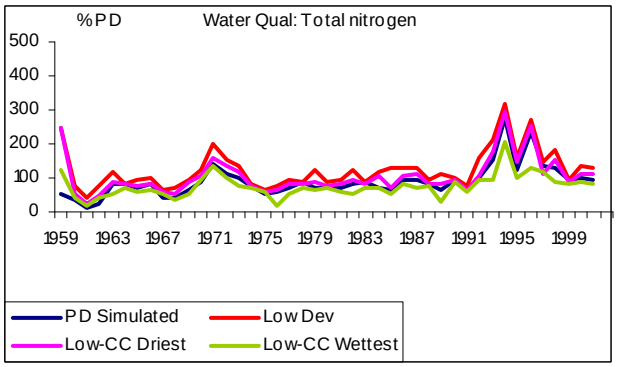
3.2.6 Total nitrogen

(In channel)- mg/l

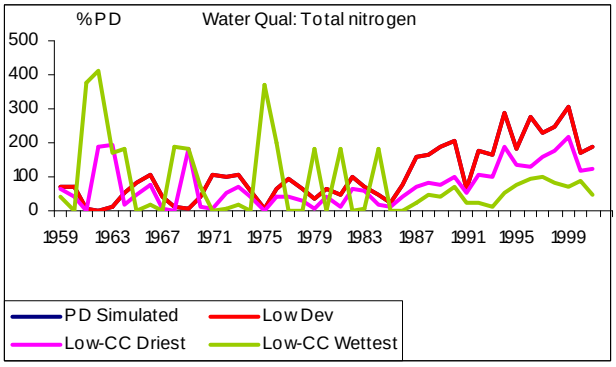
Site 1: Cubango River @ Capico



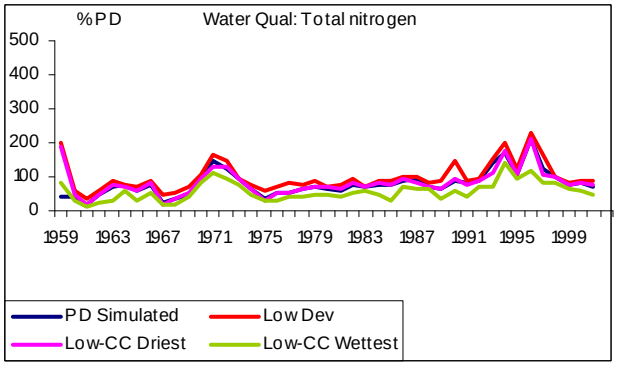
Site 2: Cubango River @ Mucundi



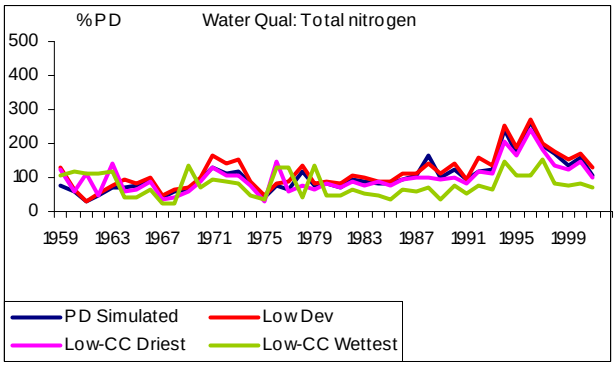
Site 3: Cuito River @ Cuito Cuanavale



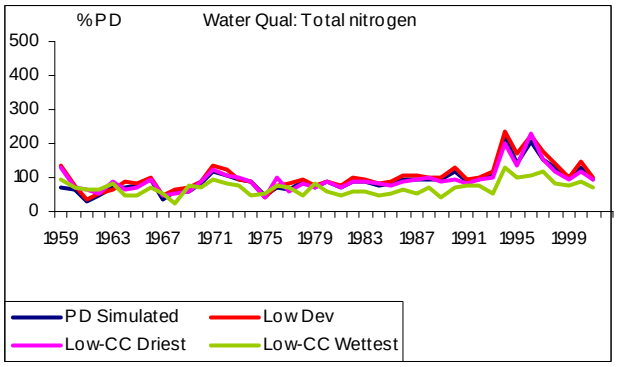
Site 4: Okavango River @ Rundu



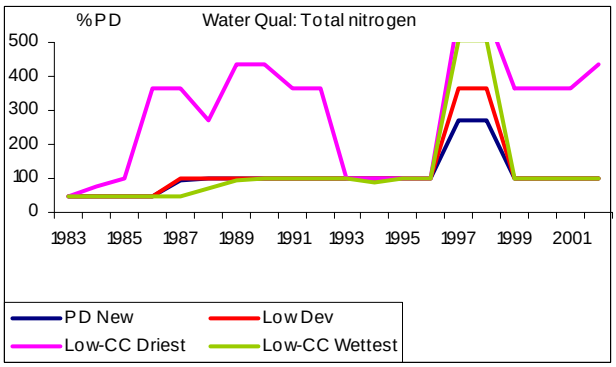
Site 5: Okavango River @ Popa Falls



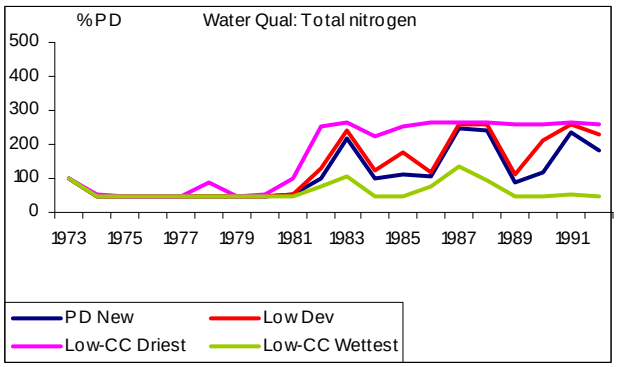
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

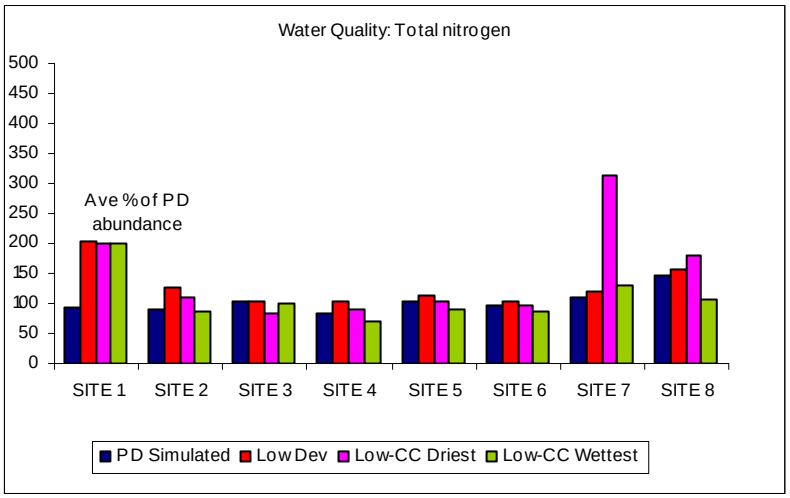


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of nitrogen.



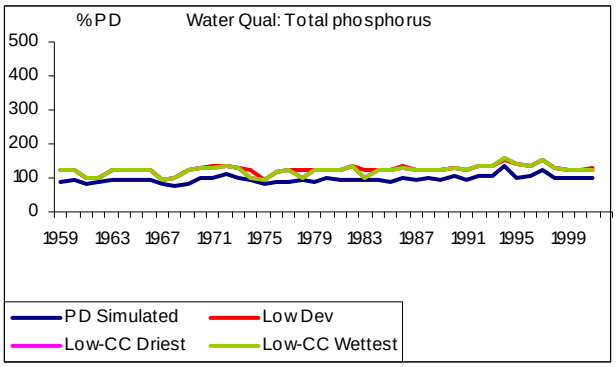
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

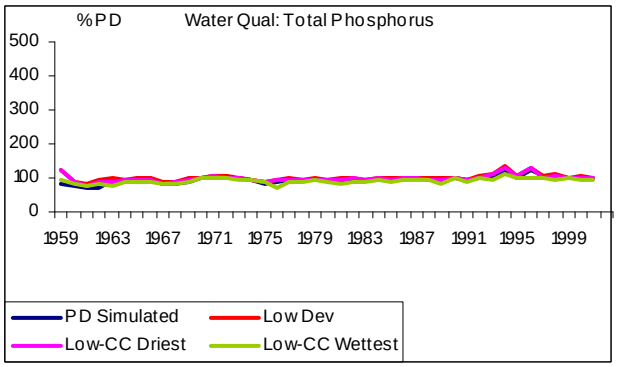
3.2.7 Total phosphorus

(In channel)- mg/l

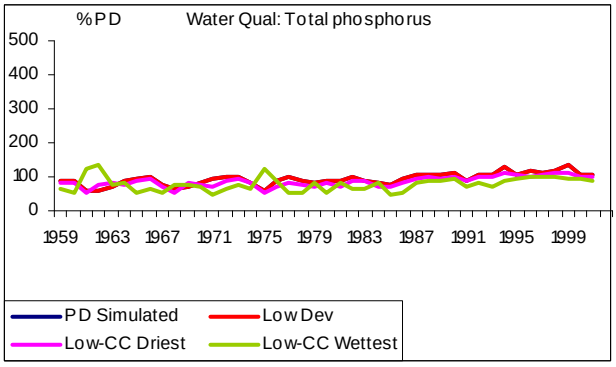
Site 1: Cubango River @ Capico



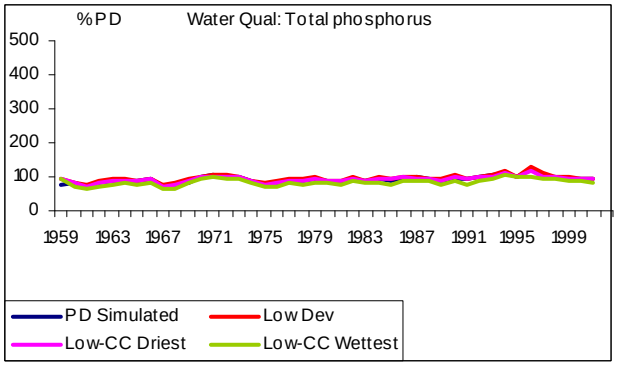
Site 2: Cubango River @ Mucundi



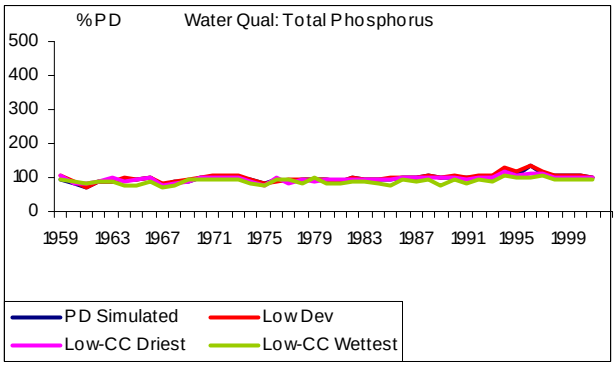
Site 3: Cuito River @ Cuito Cuanavale



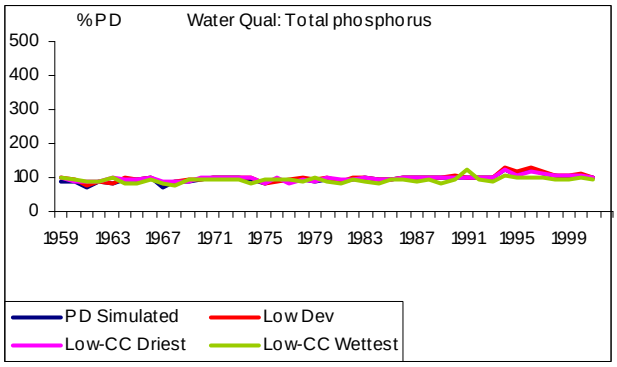
Site 4: Okavango River @ Rundu



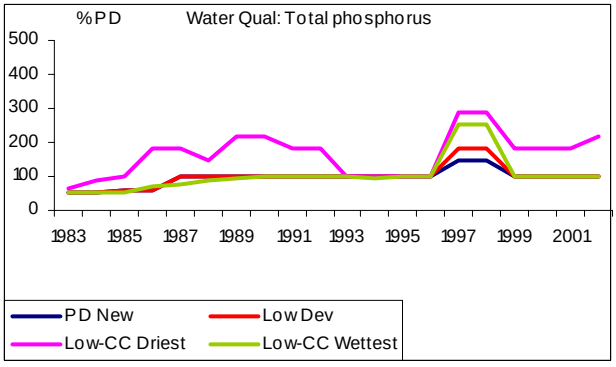
Site 5: Okavango River @ Popa Falls



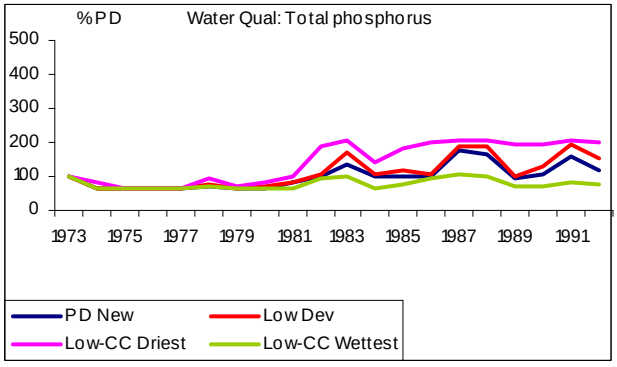
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

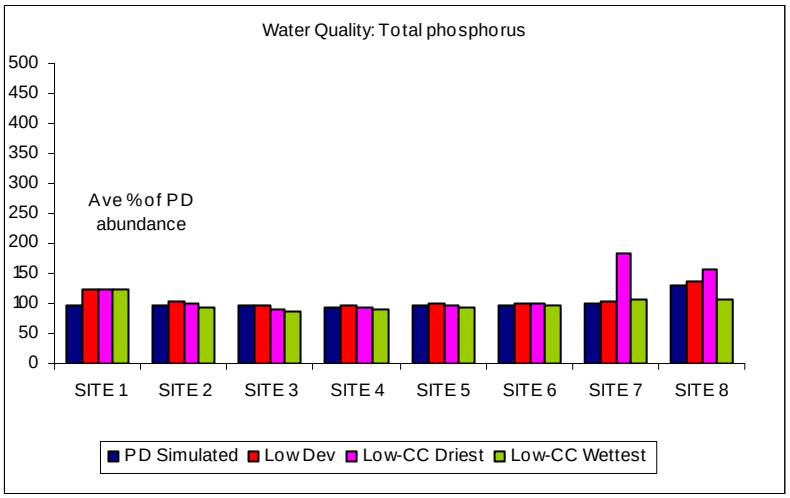


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites, but slightly lower than for total nitrogen. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of phosphorus.



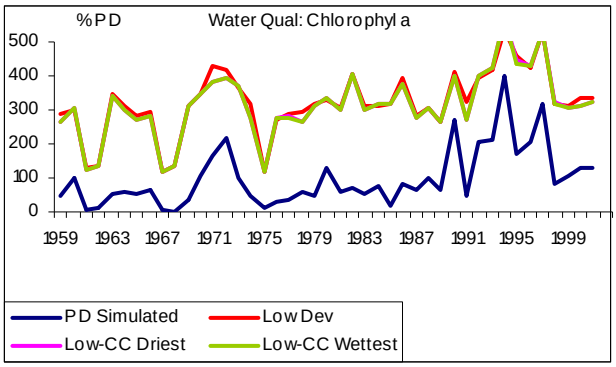
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

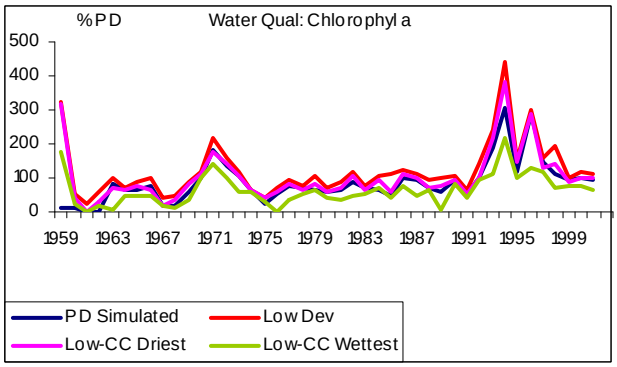
3.2.8 Chlorophyl a

(In channel)- ug/l

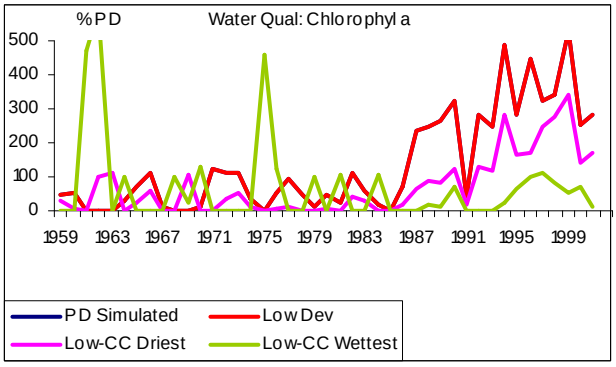
Site 1: Cubango River @ Capico



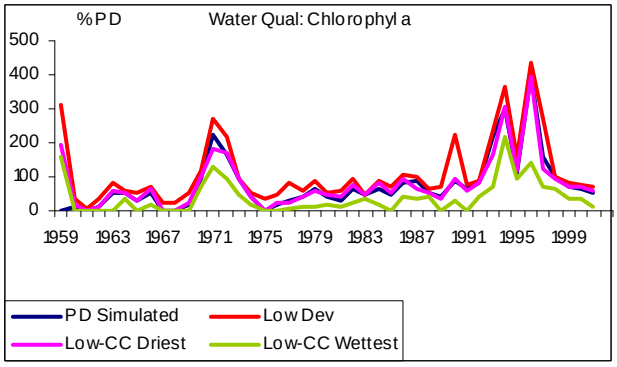
Site 2: Cubango River @ Mucundi



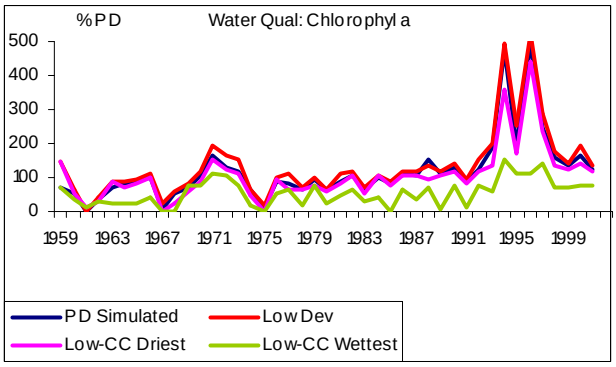
Site 3: Cuito River @ Cuito Cuanavale



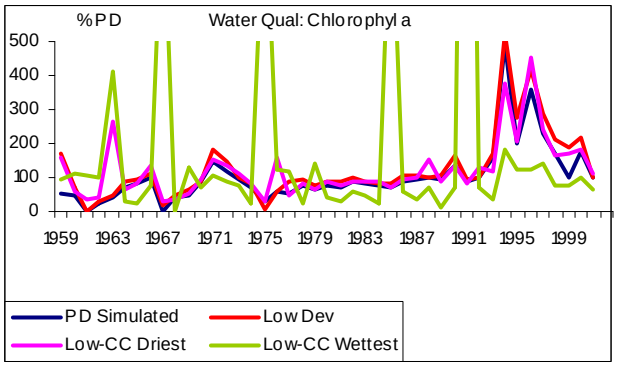
Site 4: Okavango River @ Rundu



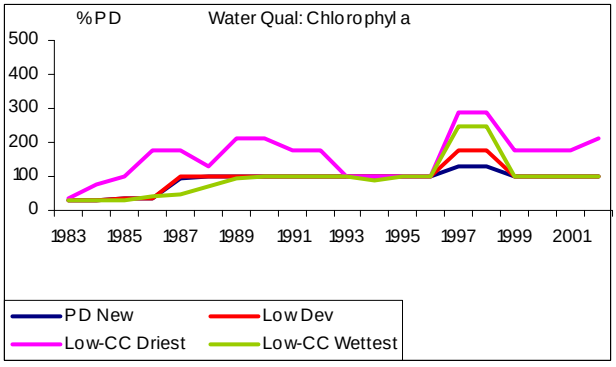
Site 5: Okavango River @ Popa Falls



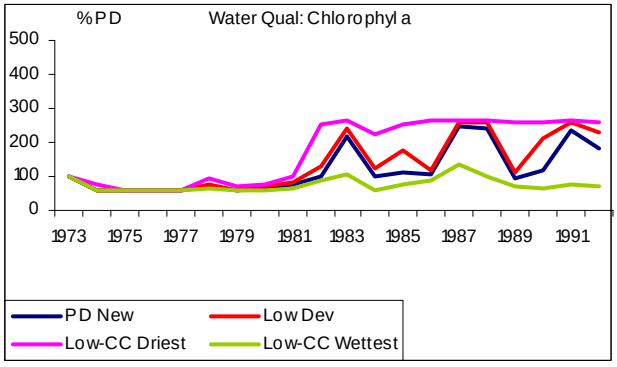
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

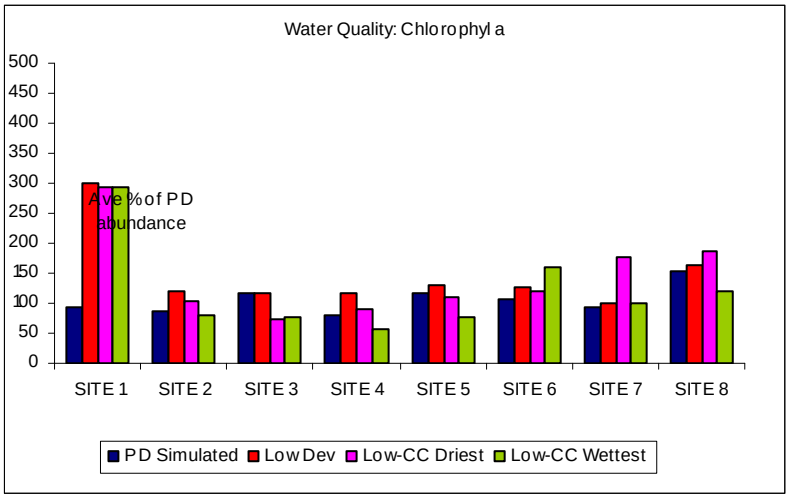


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites. The change in concentration is bigger than for total nitrates. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of chlorophyll a.



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.3. Vegetation

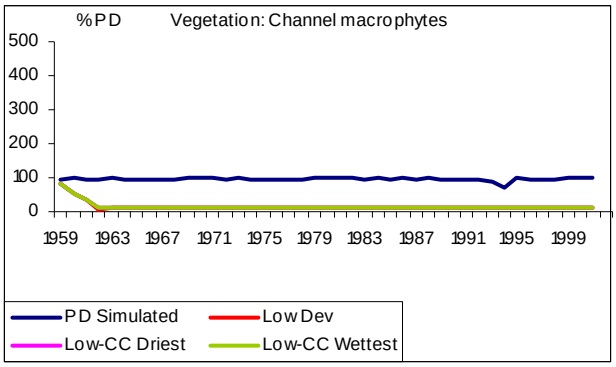
This section provides the time-series for vegetation indicators under the flow regime resulting from the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Channel macrophytes
- Lower wet bank (hippo grass, papyrus)
- Upper wet bank 1 (reeds)
- Upper wet bank 2 (trees, shrubs)
- River dry bank
- Floodplain dry bank
- Floodplain residual pools
- Lower floodplain
- Middle floodplain (grasses)
- Upper floodplain (trees,)
- Open waters
- Permanent swamps
- Lower floodplain
- Upper floodplain
- Occasionally flooded grassland
- *Sporobolus* islands
- Riparian woodland, trees
- Savanna and scrub
- Open water
- Riparian woodland, trees
- Channel-submerged vegetation
- Channel-marginal vegetation.

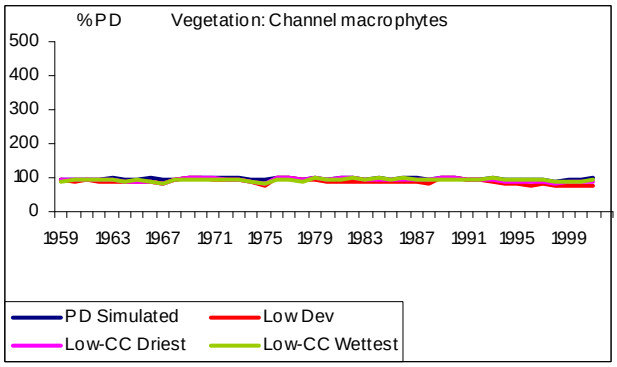
3.3.1 Channel macrophytes

(Edges of main channel or side channels. All or part of vegetation permanently submerged. Rooted or floating. Moving water.)- Potamogeton spp., Vallisneria, Lagarosiphon

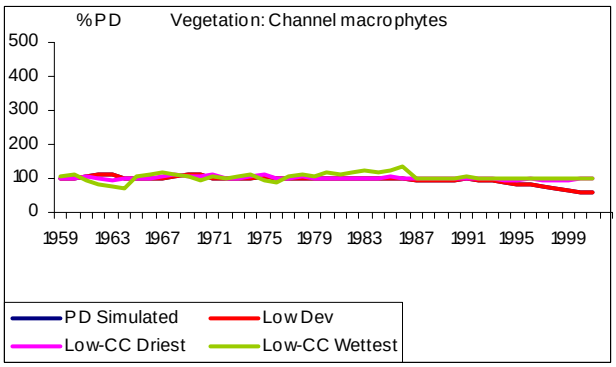
Site 1: Cubango River @ Capico



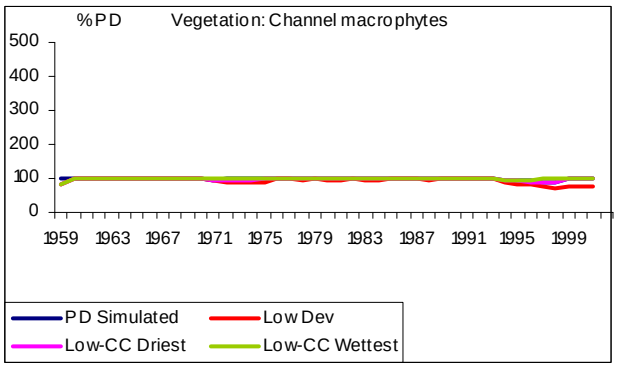
Site 2: Cubango River @ Mucundi



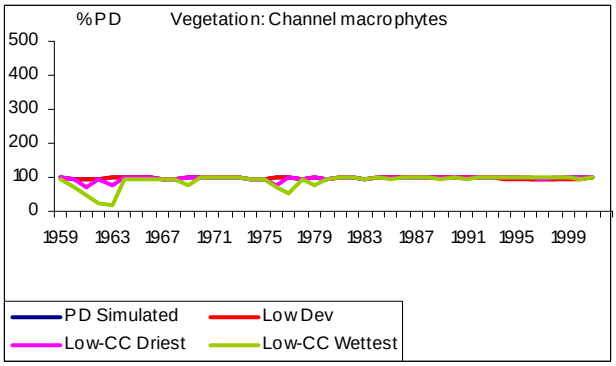
Site 3: Cuito River @ Cuito Cuanavale



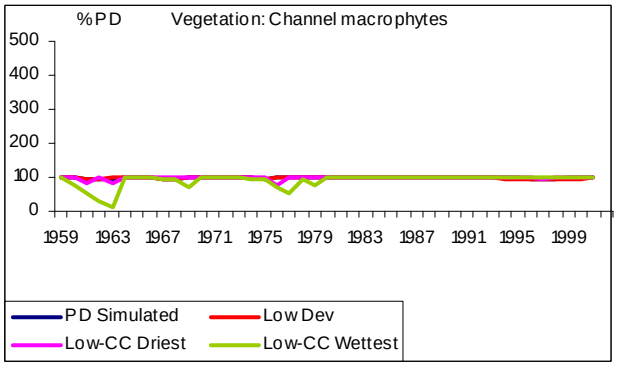
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

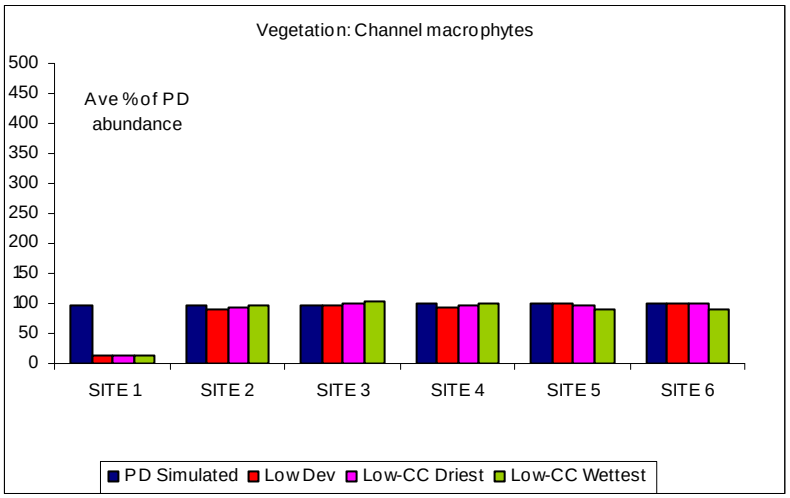


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Cover increases or decreases depending on water volume in dry season and could decline to zero if dry season channel dries. Sudden or very large floods could reduce cover. Onset and duration of either season of little impact.



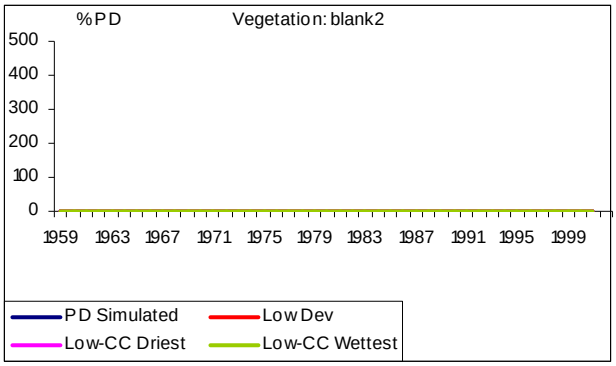
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

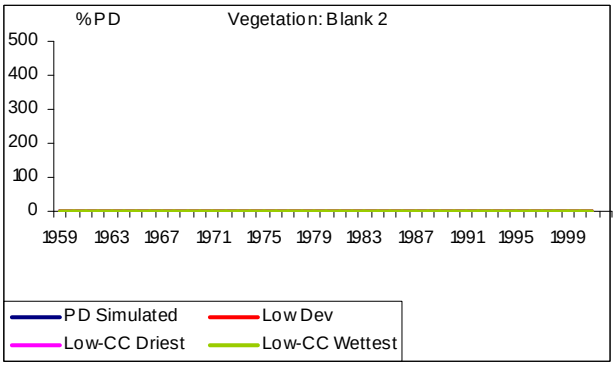
3.3.2 Lower wet bank (hippo,papyrus)

(Permanently wet inner margin in main channel. Floating plants with stems forming dense mat; leaves and flowers above water. Rooted in sand/peat. Moving water.)- Vossia cuspidata, Cyperus papyrus

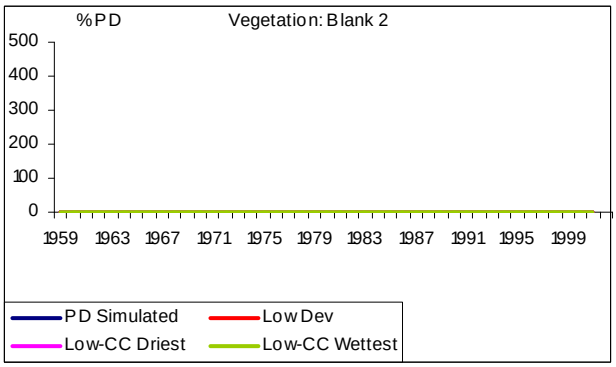
Site 1: Cubango River @ Capico



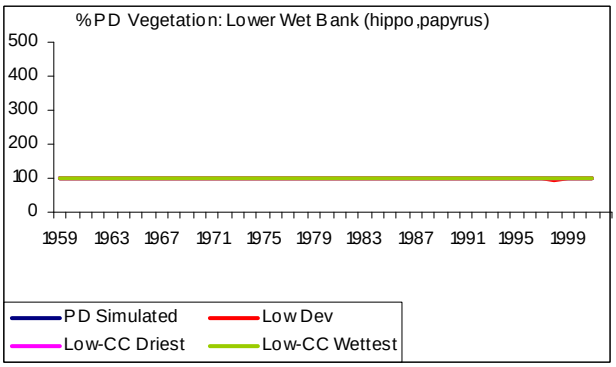
Site 2: Cubango River @ Mucundi



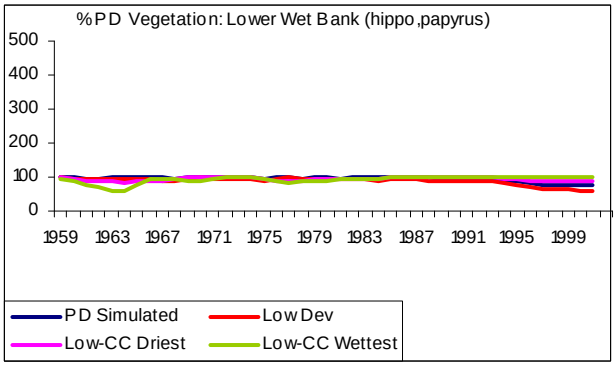
Site 3: Cuito River @ Cuito Cuanavale



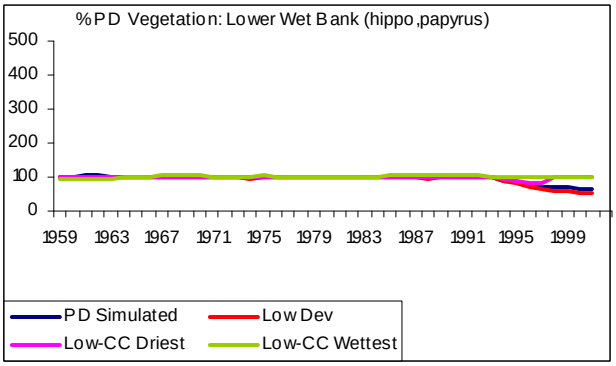
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

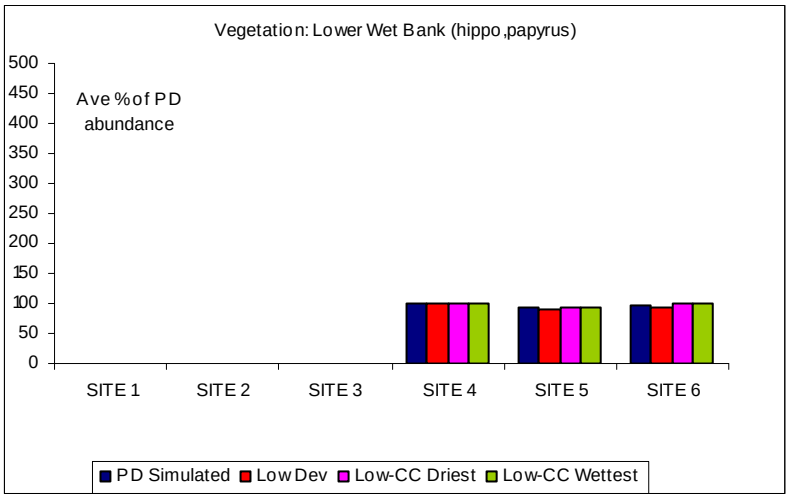


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Vossia will mimic the flow of the river as long as there is water to cover its roots. The leaves will float higher or lower as water level rises or falls. It can tolerate more dessication than can papyrus. Papyrus roots must also be



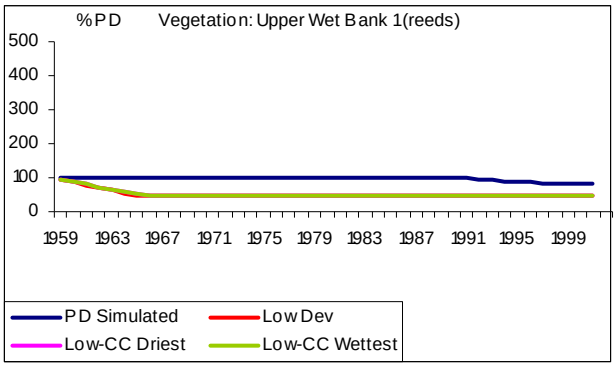
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

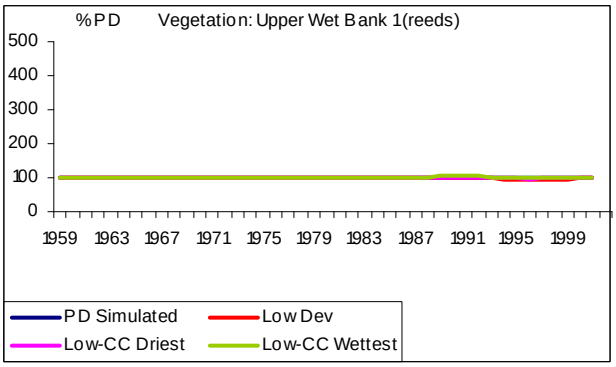
3.3.3 Upper wet bank 1 (reeds)

(Outer edges of the mainstream, beyond inner margin. Emergent vegetation with roots generally wet, but can withstand being out of water. Moving water.)- Phragmites australis

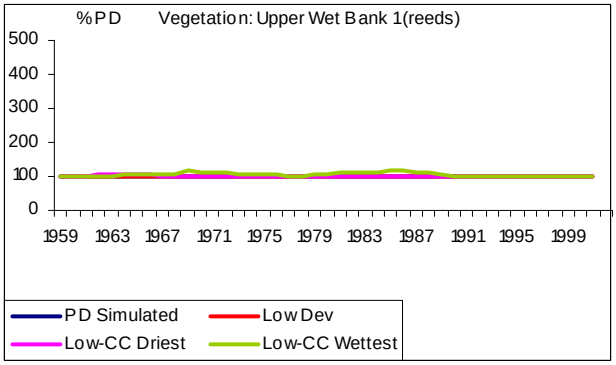
Site 1: Cubango River @ Capico



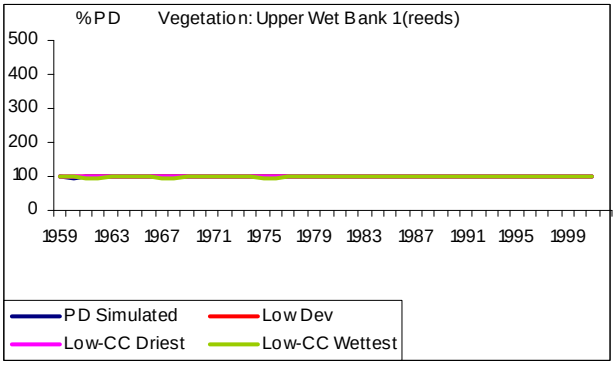
Site 2: Cubango River @ Mucundi



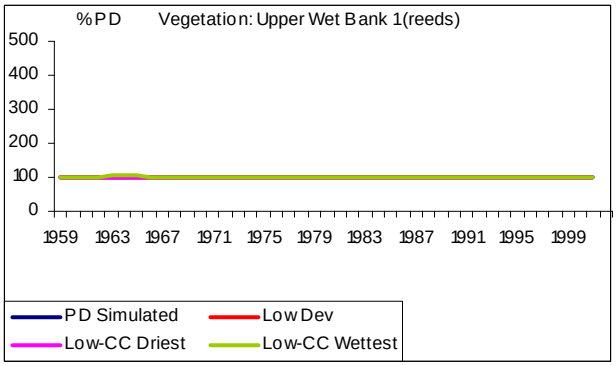
Site 3: Cuito River @ Cuito Cuanavale



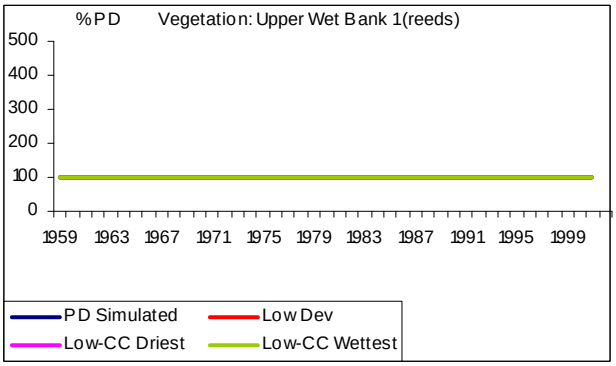
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

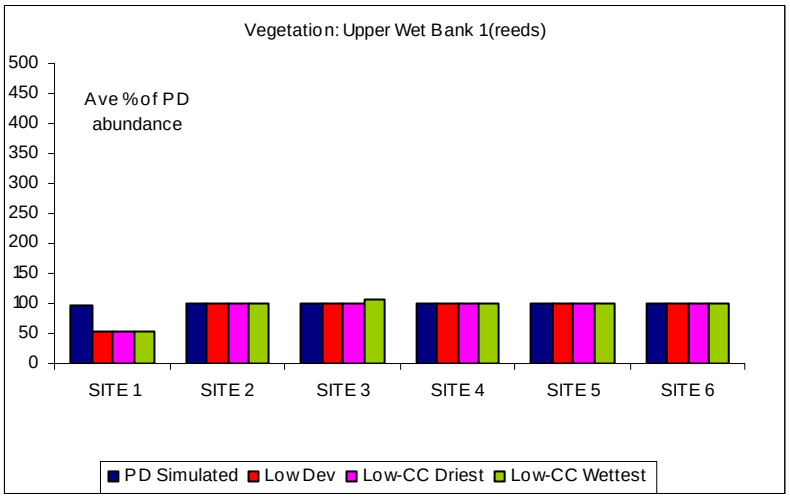


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Water depth (>2 m?) inhibits growth in channel. Declines in dry season flows will encourage colonisation of channel bottom with some die-off of the upper margin of reed bed. Flood season has little impact, but new growth could decrease in strong floods.



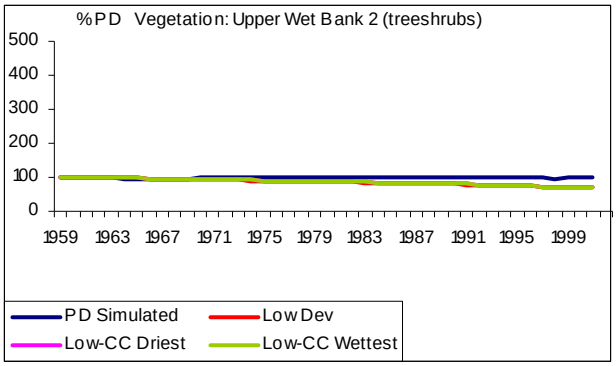
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

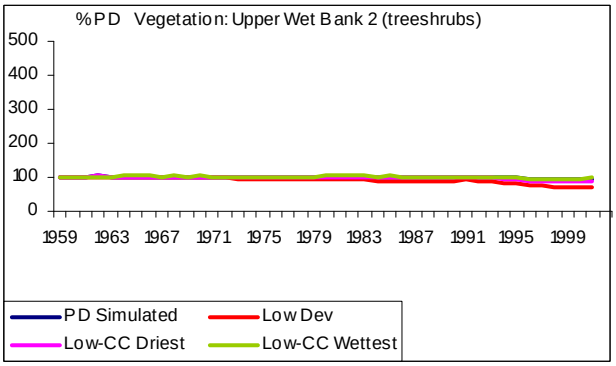
3.3.4 Upper wet bank 2 (treeshrubs)

(Wetted edge of main channel (or river islands) at high flow. Higher than Lower Wet Bank. Trees & shrubs typical of riparian zone. Can be submerged for short periods)- Searsia (Rhus), Syzigium etc.

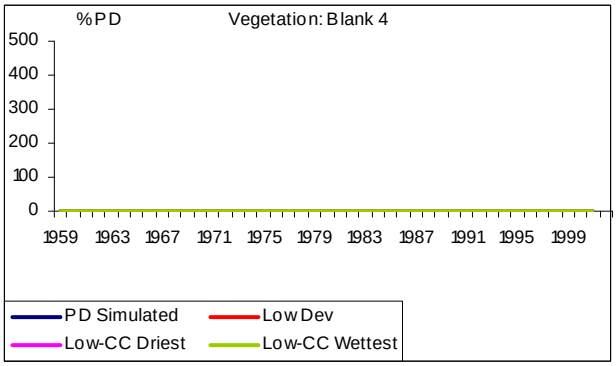
Site 1: Cubango River @ Capico



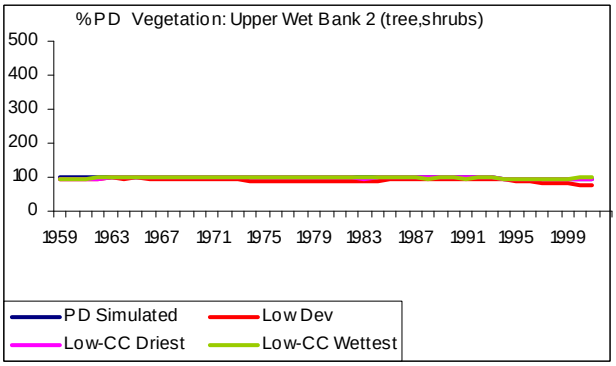
Site 2: Cubango River @ Mucundi



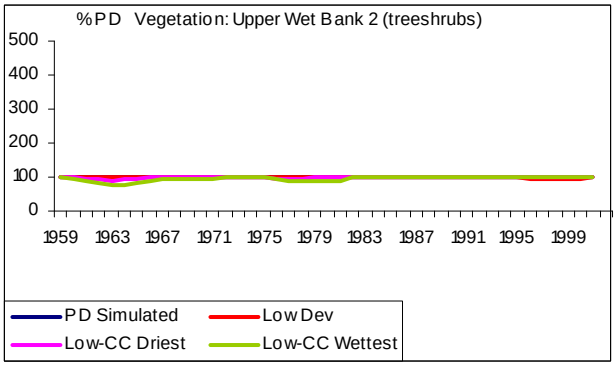
Site 3: Cuito River @ Cuito Cuanavale



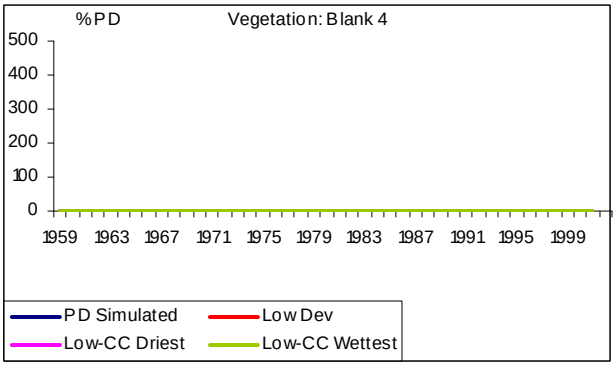
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

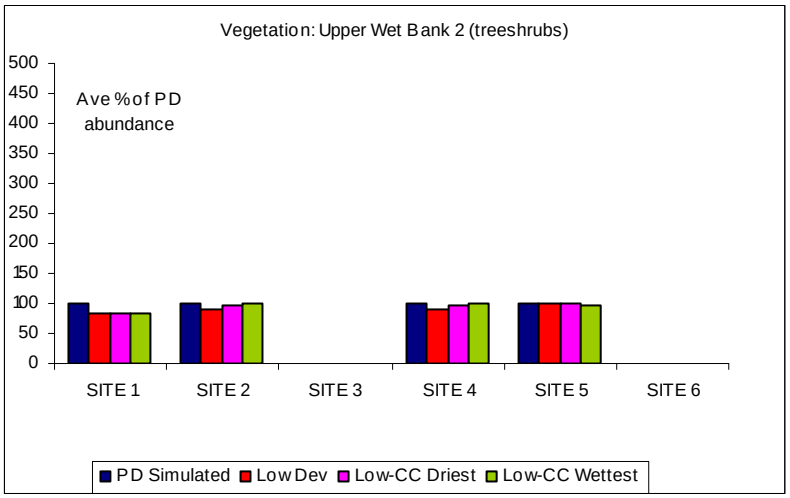


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Can withstand inundation, but too long (>3 months?) will kill trees. Smaller floods will allow colonisation by terrestrial species on the outer edge. These wetbank trees will be squeezed into a smaller zone, decreasing cover. Too long a dry season will reduce recruitment and adult vigour.



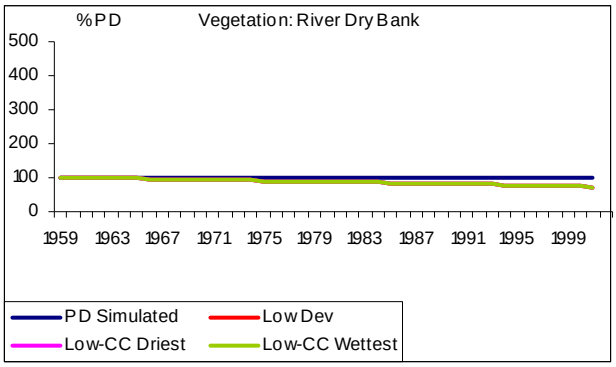
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

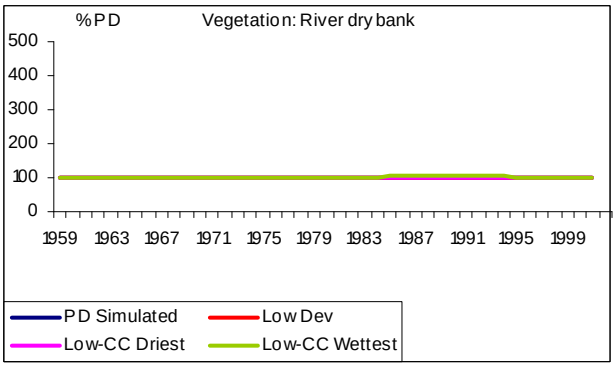
3.3.5 River dry bank

(Riparian woodlands found on the high dry bank of river channels.)- Diospyros mespiliformis, with Acacia nigrescens, Combretum imberbe, Ficus sycomorus.

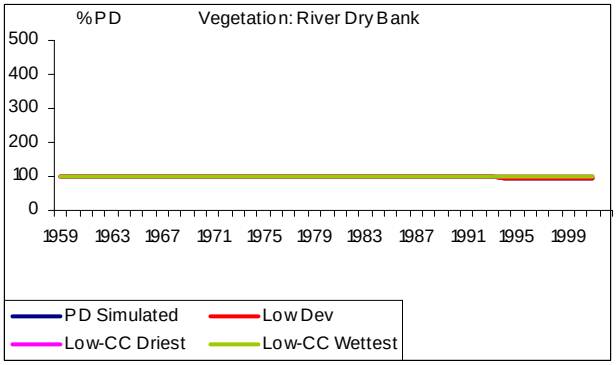
Site 1: Cubango River @ Capico



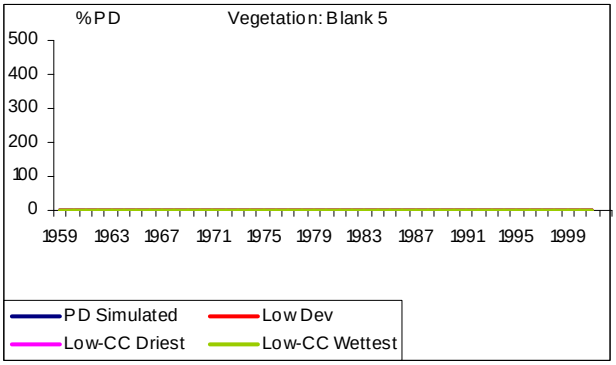
Site 2: Cubango River @ Mucundi



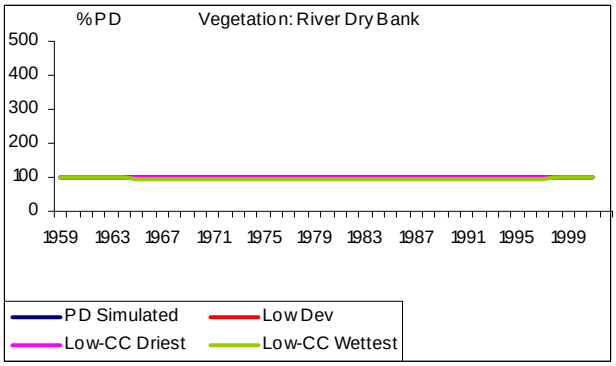
Site 3: Cuito River @ Cuito Cuanavale



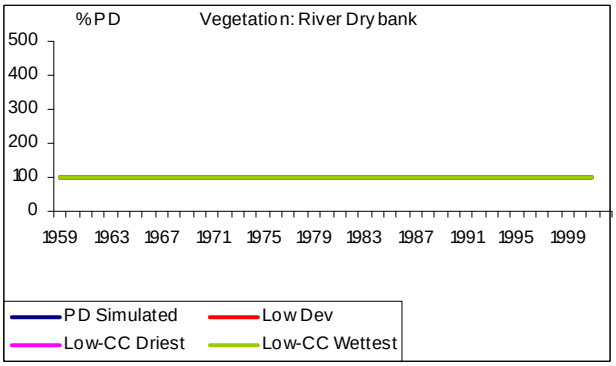
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

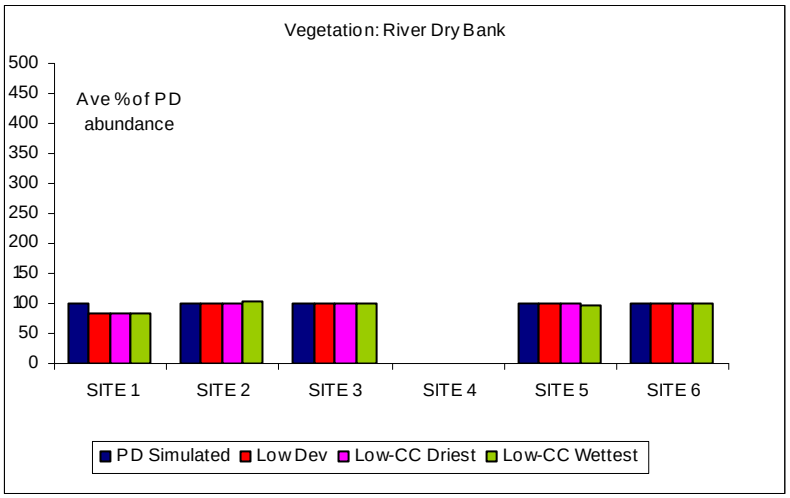


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Stabilises bank. Adults will decrease with very low dry season flow as water table may drop below reach of roots. Seedlings will decline with shorter flood seasons because of lower soil moisture levels. Decline in community could take up to 3 - 4 decades.



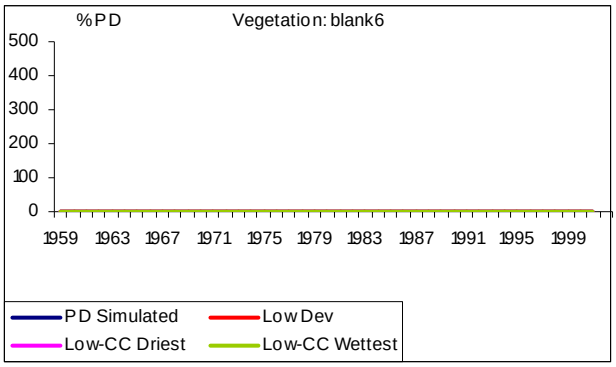
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

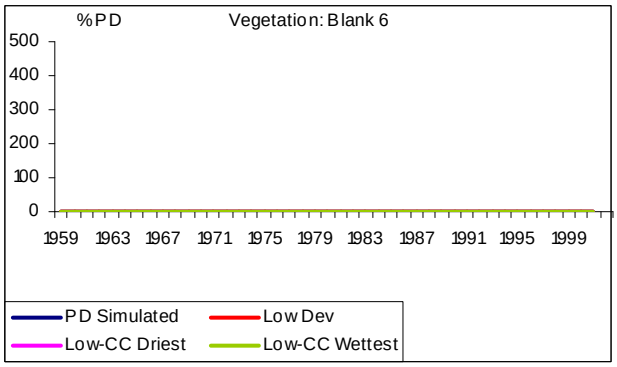
3.3.6 Floodplain residual pools, open water

(Permanent floodplain pools. Connected to river during high flow but retain water at normal low flow)- Nymphaea, Nymphoides, Lagarosiphon, Trapa.

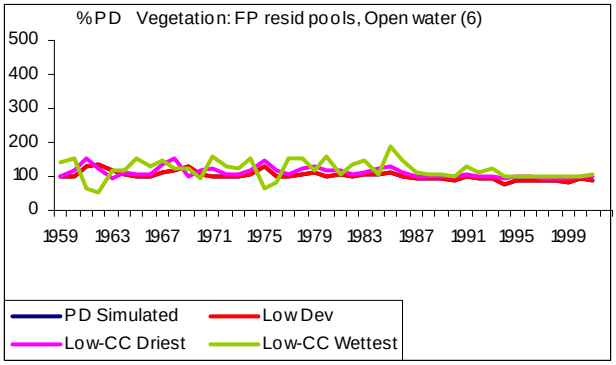
Site 1: Cubango River @ Capico



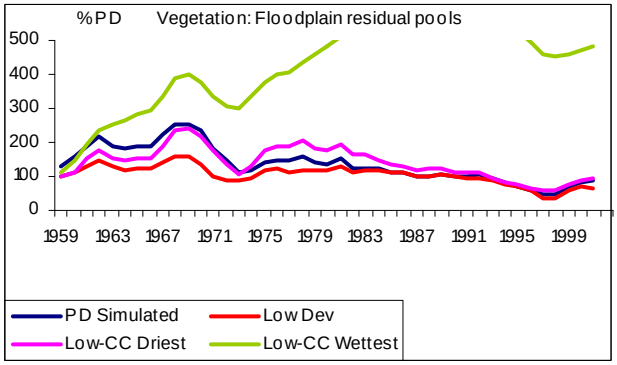
Site 2: Cubango River @ Mucundi



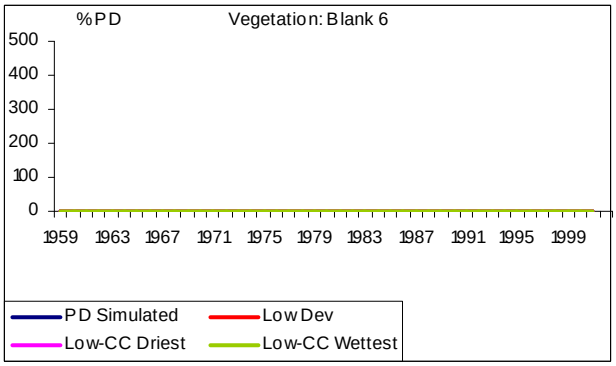
Site 3: Cuito River @ Cuito Cuanavale



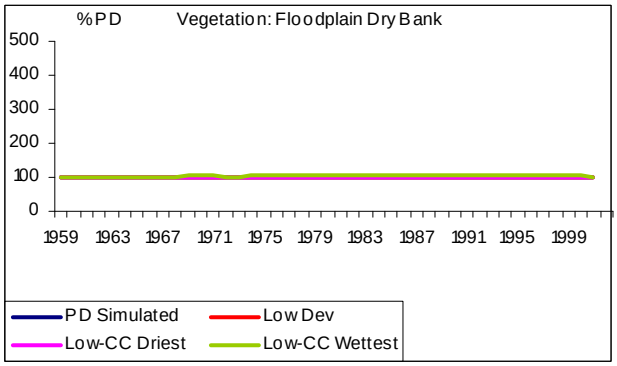
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

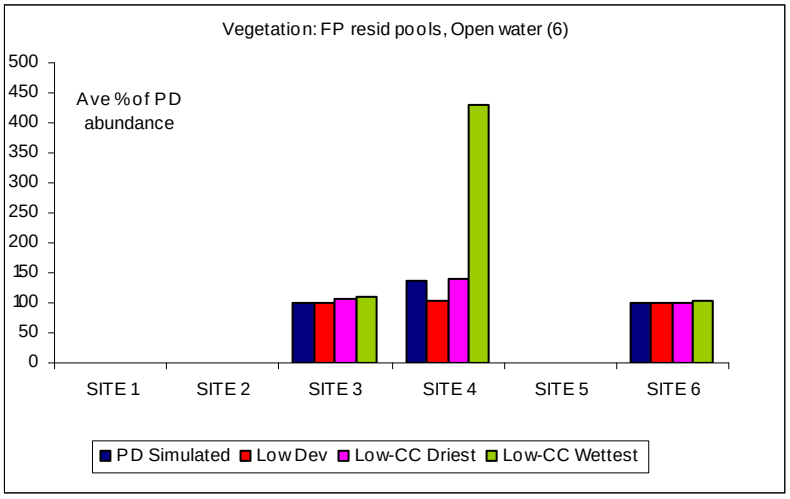


Site 6: Okavango River @ Pan Handle



Summary change per scenario

These are permanent pools that are replenished in the flood. With no flooding, they will decrease in size due to evaporation. With larger floods they could increase in size.



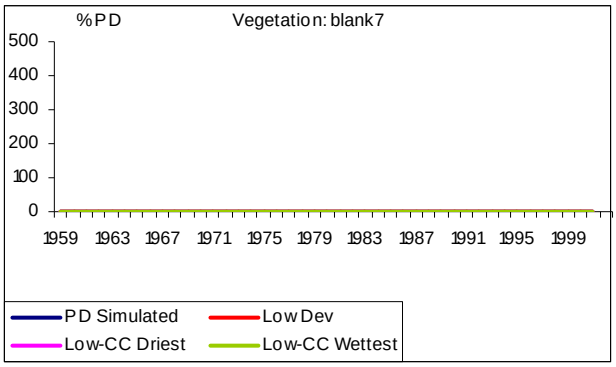
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

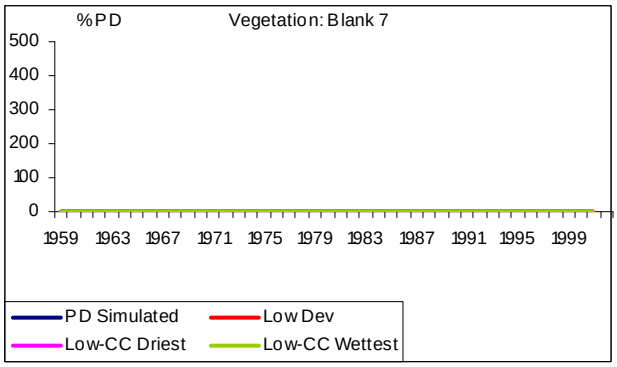
3.3.7 Lower floodplain

(Lower floodplain with long inundation. The deeper sections of channels between scroll bars that flood and dry out seasonally)- Vossia cuspidata with Persicaria, Ludwigia, etc

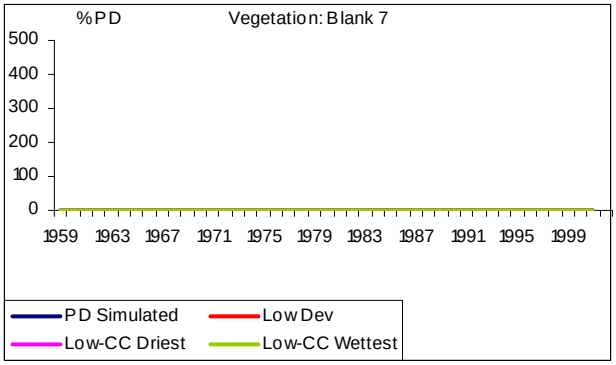
Site 1: Cubango River @ Capico



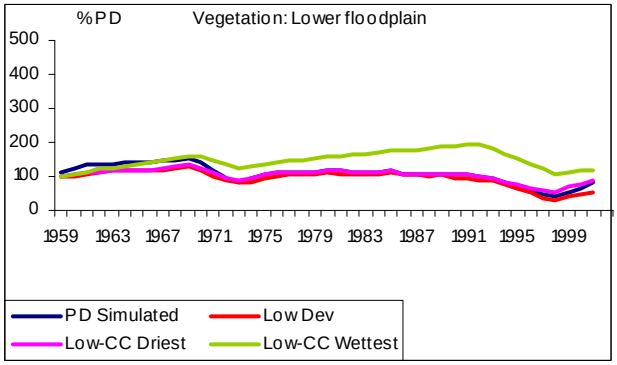
Site 2: Cubango River @ Mucundi



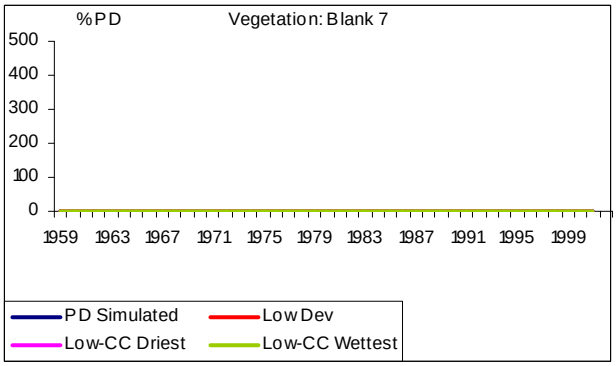
Site 3: Cuito River @ Cuito Cuanavale



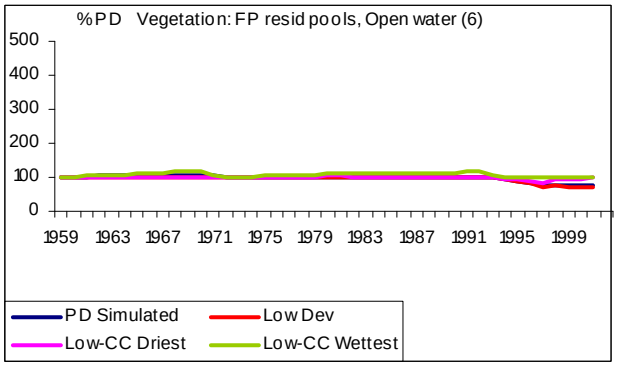
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

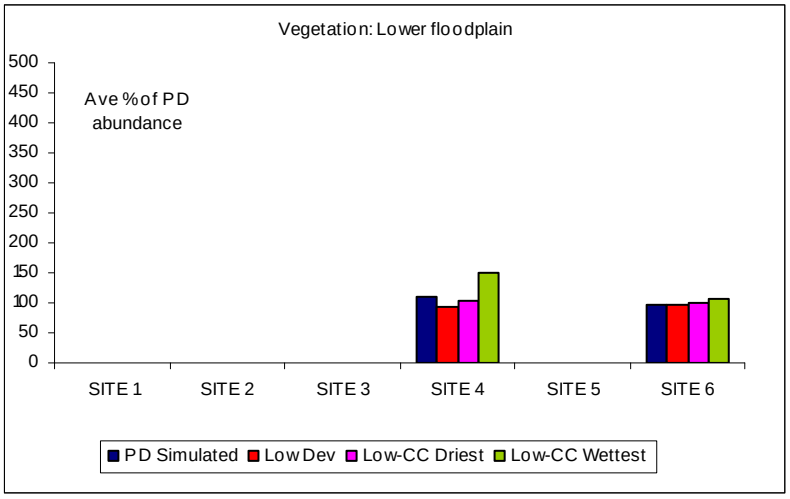


Site 6: Okavango River @ Pan Handle



Summary change per scenario

This is seasonal and dependent on recharge by floods. They mimic the flood levels from year to year. In wet years they will increase in size, in dry years they will decrease.



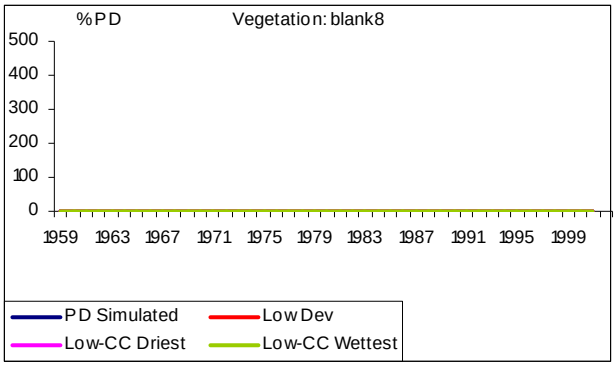
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

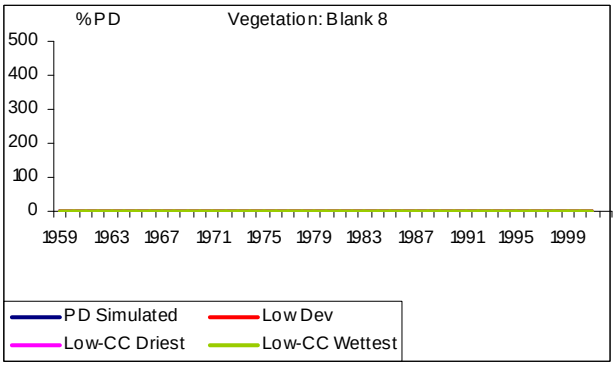
3.3.8 Middle floodplain (grasses)

(Middle floodplain, clay or sand, with short inundation. Large area with thatching and grazing grasses. Includes portions of upper floodplain (but not islands))- Setaria, Panicum, thatching grasses

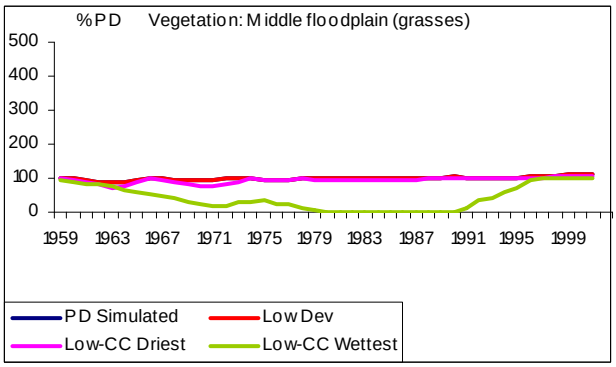
Site 1: Cubango River @ Capico



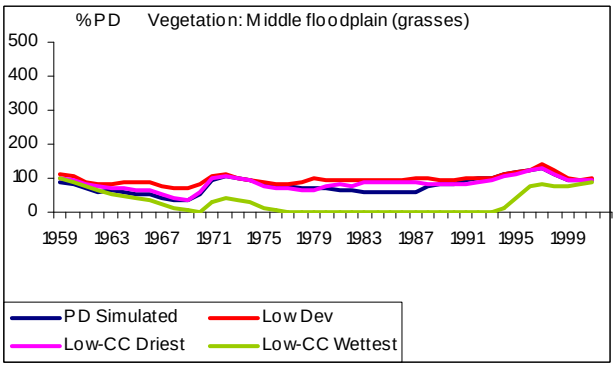
Site 2: Cubango River @ Mucundi



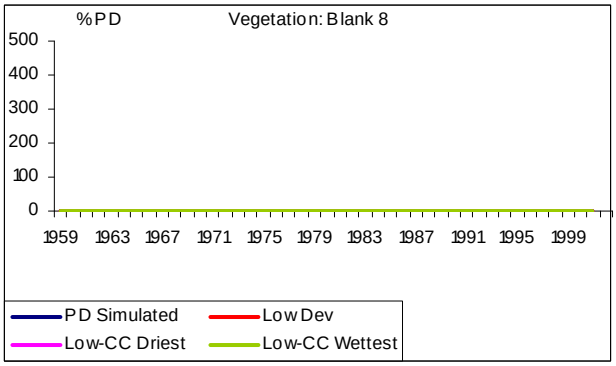
Site 3: Cuito River @ Cuito Cuanavale



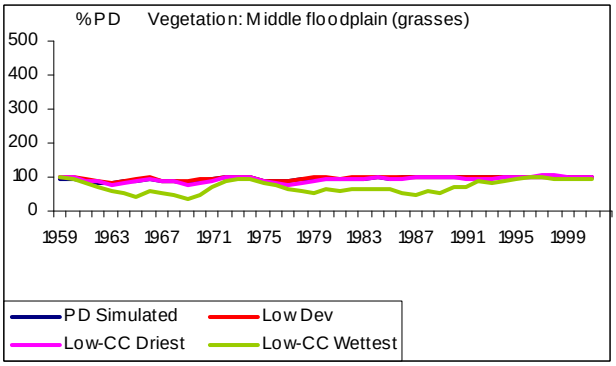
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

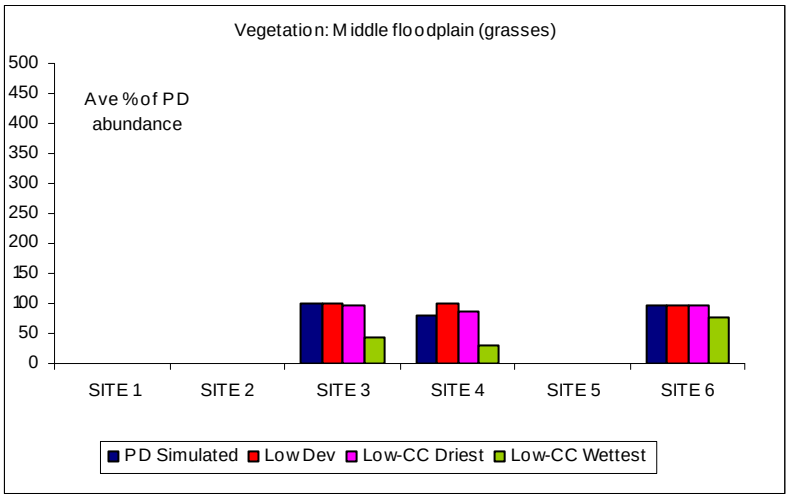


Site 6: Okavango River @ Pan Handle



Summary change per scenario

These are basically terrestrial grasses that can withstand a degree of inundation in the wet season. With a longer wet season, there will be a decrease in area of these plants, and vice versa. Flooding during growing season reduces productivity



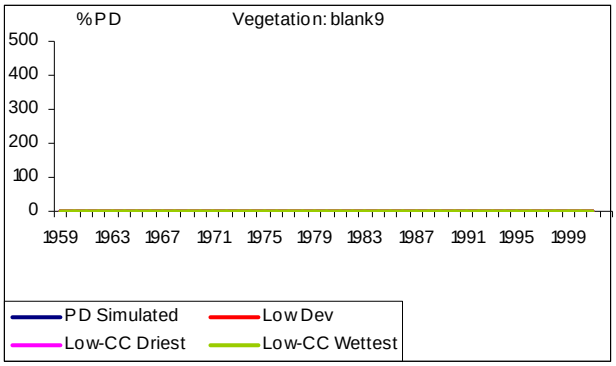
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

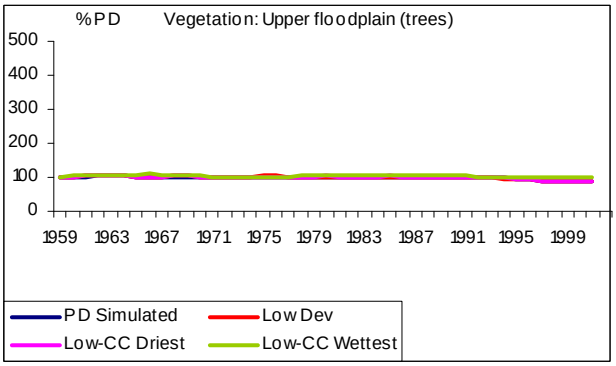
3.3.9 Upper floodplain (trees, rhus)

(The highest points on the floodplain. Only inundated during high flow. Grasses, shrubs, a few trees. Equals wildlife secondary floodplain. Therefore is primarily floodplain islands. Searsia (Rhus) with Acacia hebeclada, Acacia sieberiana, Diospyros lycioides, grasses.

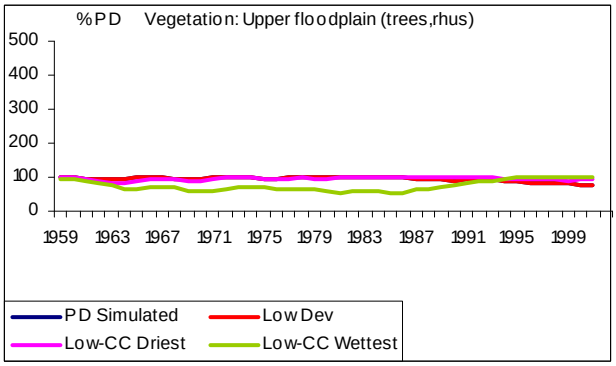
Site 1: Cubango River @ Capico



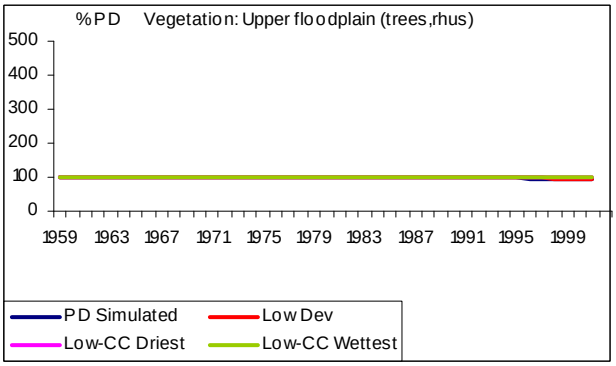
Site 2: Cubango River @ Mucundi



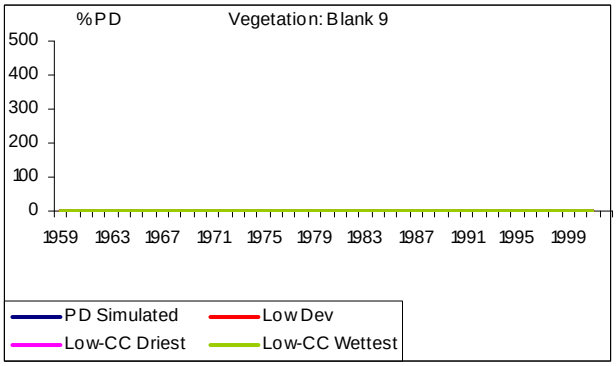
Site 3: Cuito River @ Cuito Cuanavale



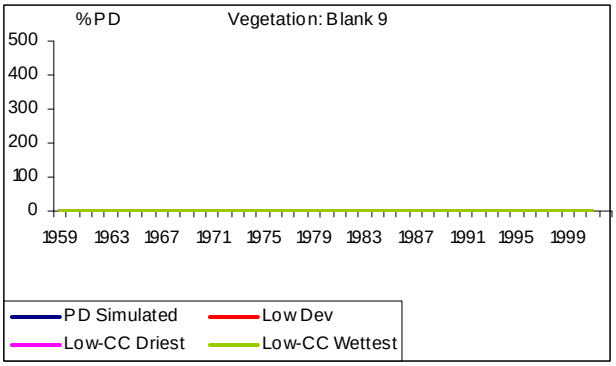
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

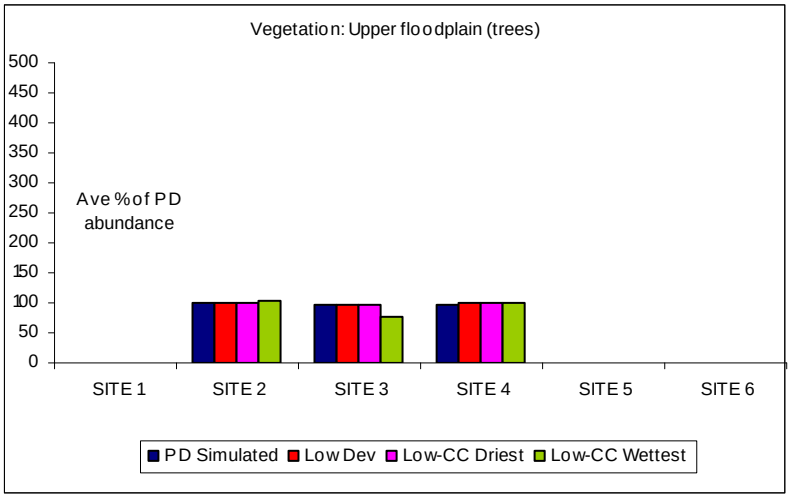


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Seldom inundated. Long inundation is detrimental to these plants. Dependent on some inundation to recharge ground water, and for nutrients.



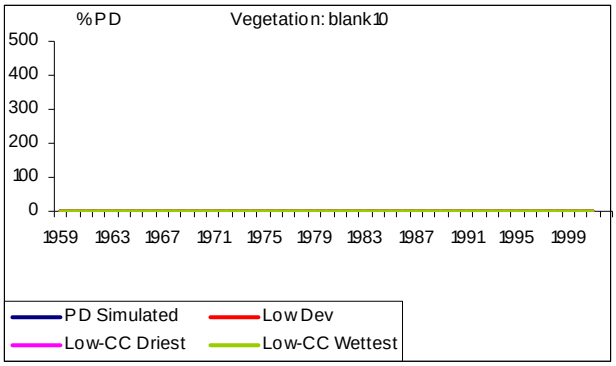
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

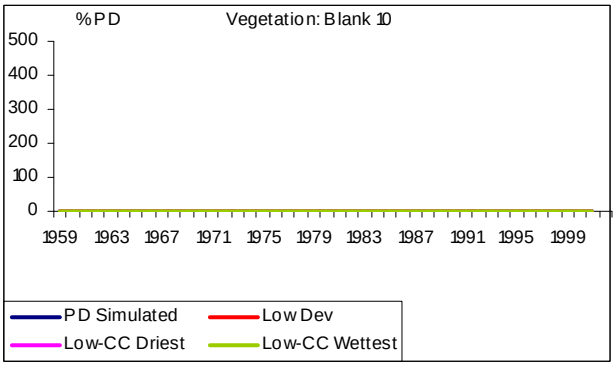
3.3.10 Floodplain dry bank

(Dry river bank on outer edge of floodplain. Seldom to never flooded. Riparian species that need to be close to water.) - Diospyros mespiliformis, with Combretum imberbe, Albizia versicolor, Acacia hebeclada & tortilis, etc.

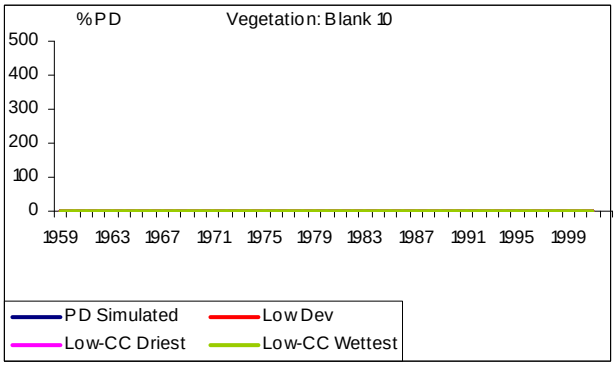
Site 1: Cubango River @ Capico



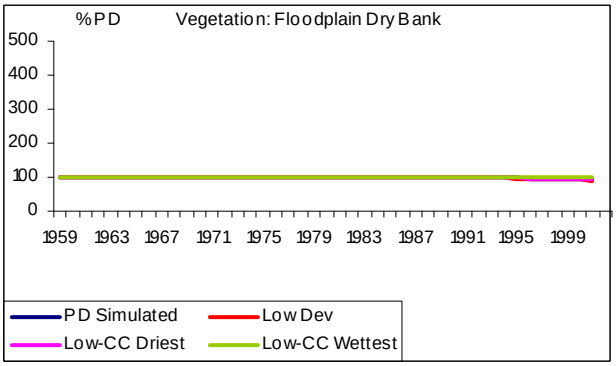
Site 2: Cubango River @ Mucundi



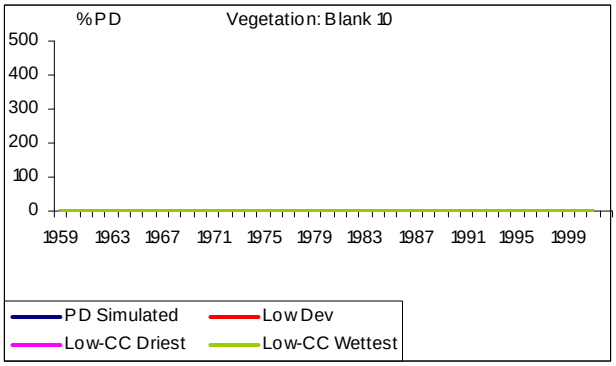
Site 3: Cuito River @ Cuito Cuanavale



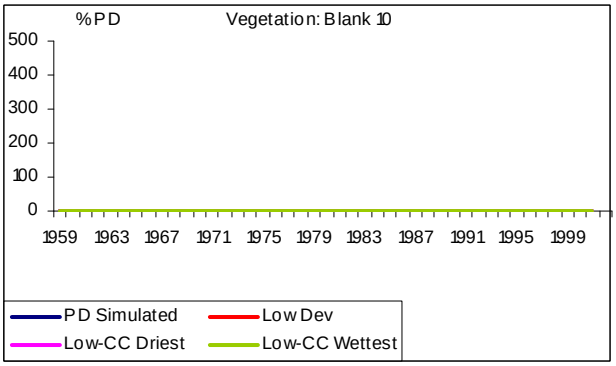
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

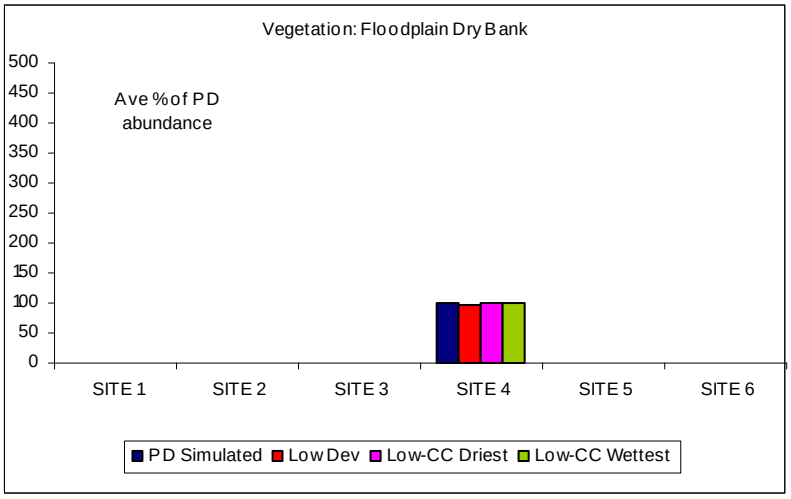


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Stabilises bank. More dependent on floods than river dry bank as water has to cross an extensive floodplain to recharge the ground water. Adults will decrease with low floods and long dry seasons as water table may drop below reach of roots. Seedlings will decline with shorter flood seasons because of lower soil moisture levels. Decline in community could take up to 2 - 3 decades.

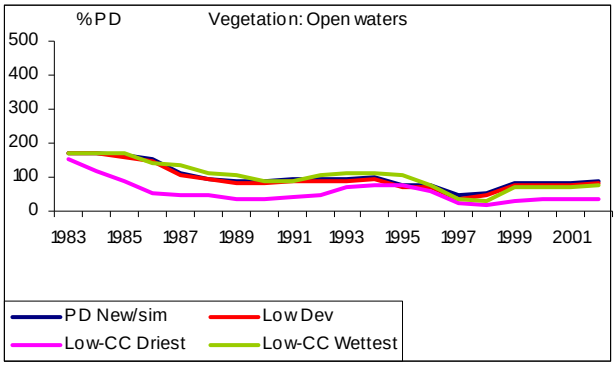


References

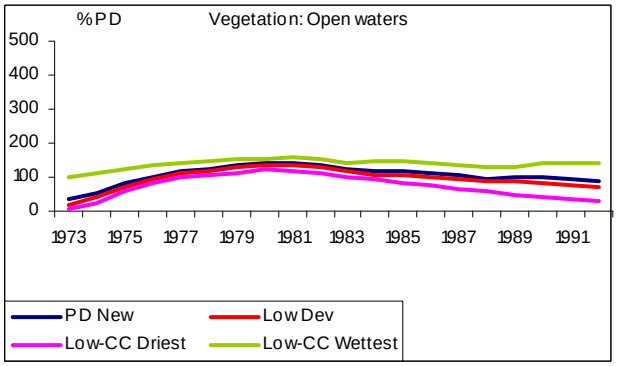
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.3.11 Open waters

Site 7: Okavango River @ Xakanaxa

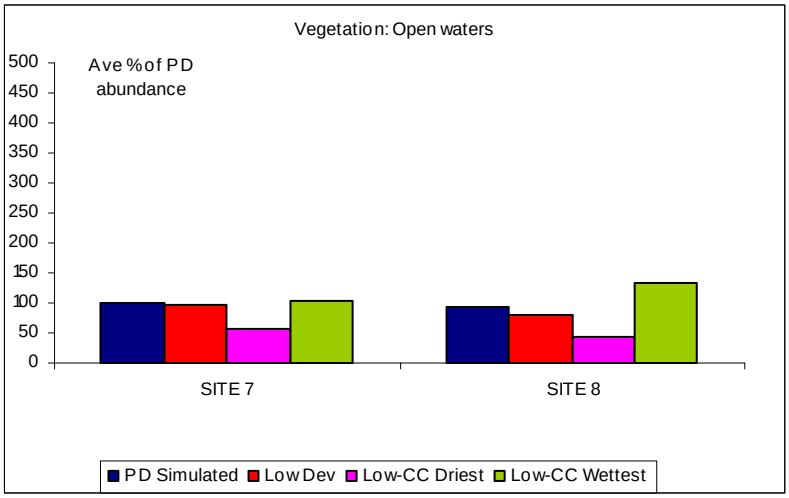


Site 8: Boteti River



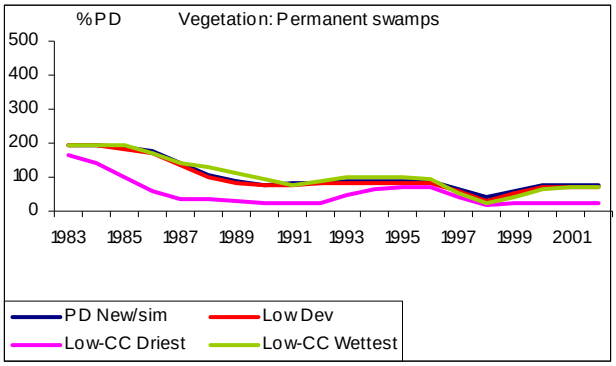
Summary change per scenario

Vegetation sensitive to changes in water depth, rate of flow, nutrients and sediments.

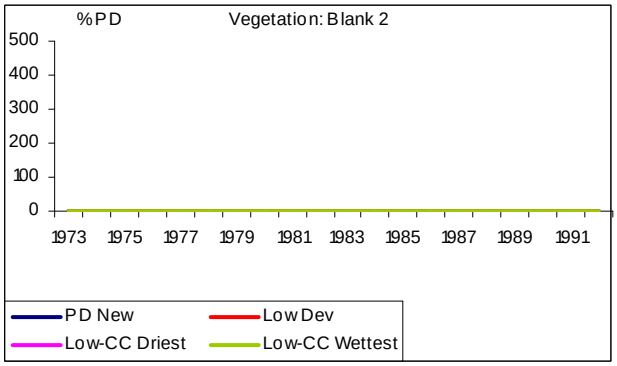


3.3.12 Permanent swamps

Site 7: Okavango River @ Xakanaxa

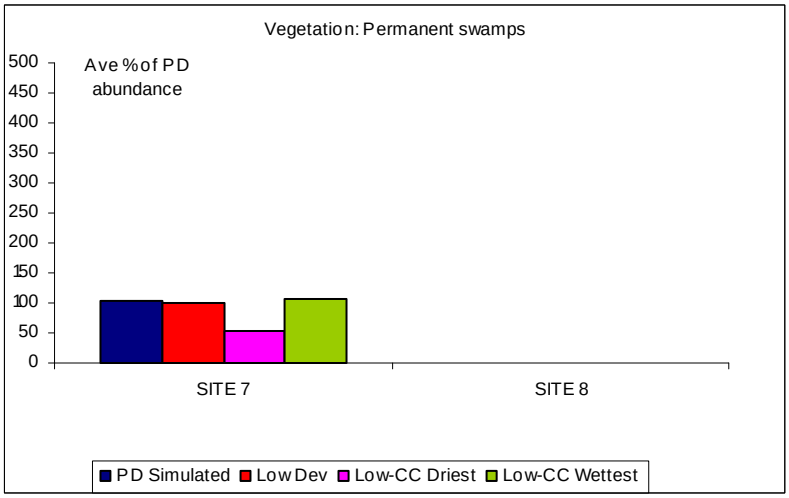


Site 8: Boteti River



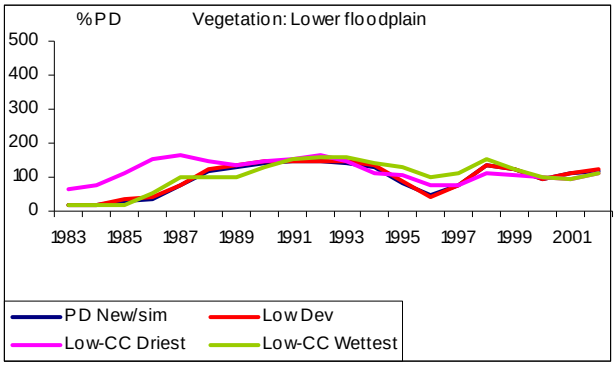
Summary change per scenario

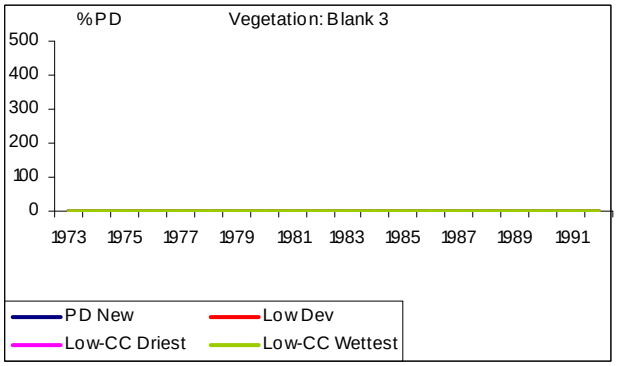
More sensitive to soil moisture content. As long as soil is saturated, depth is not important.



3.3.13 Lower floodplain

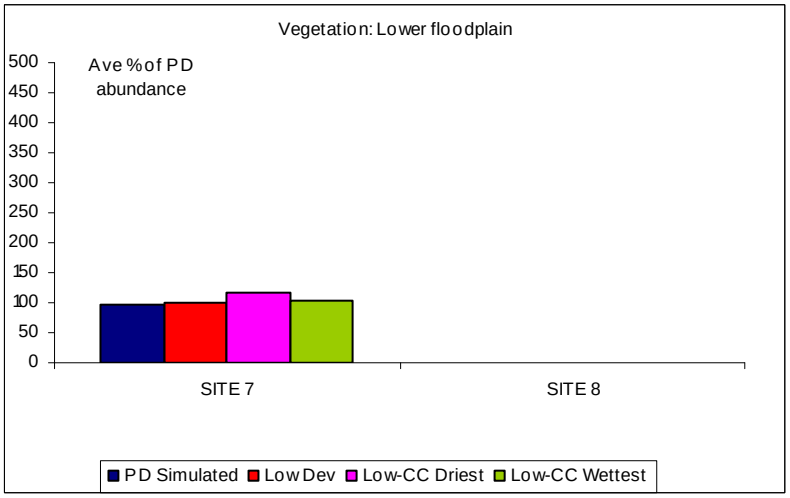
Site 7: Okavango River @ Xakanaxa Site 8: Boteti River





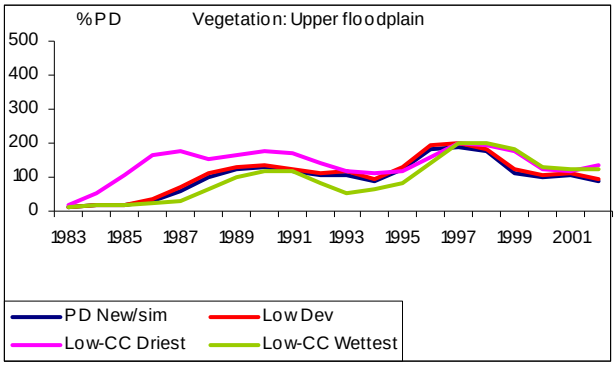
Summary change per scenario

Sensitive to duration and frequency of flooding. Long duration of flood correlates with depth of water.

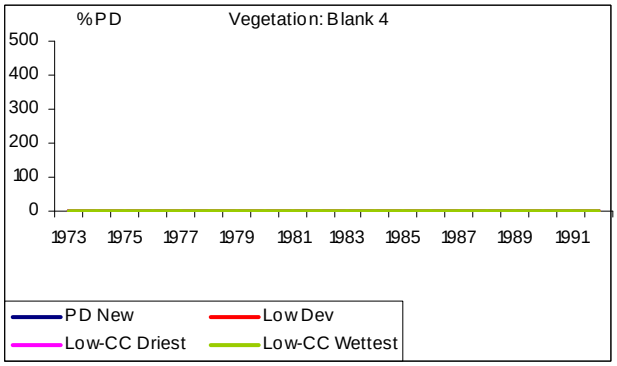


3.3.14 Upper floodplain

Site 7: Okavango River @ Xakanaxa

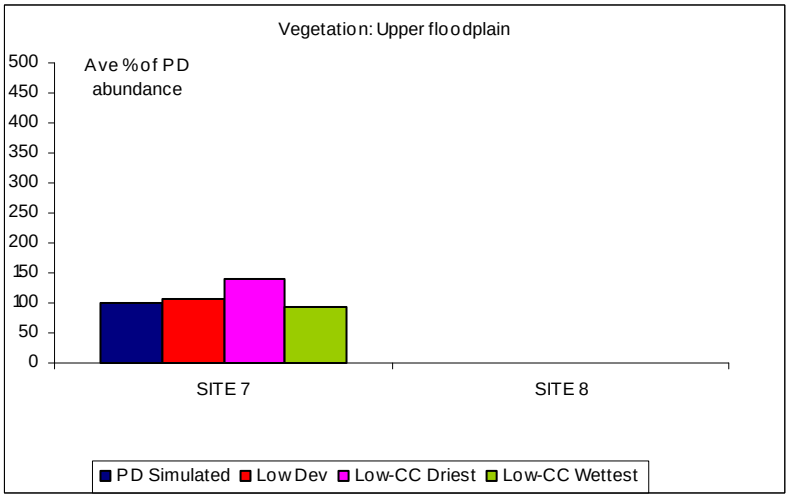


Site 8: Boteti River



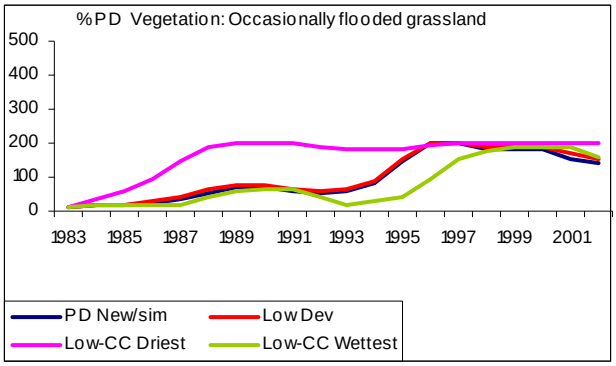
Summary change per scenario

Sensitive to duration and frequency of flooding. Long duration of flood correlates with depth of water.

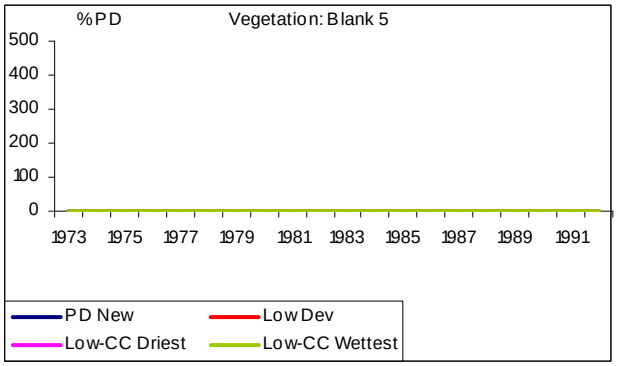


3.3.15 Occasionally flooded grassland

Site 7: Okavango River @ Xakanaxa

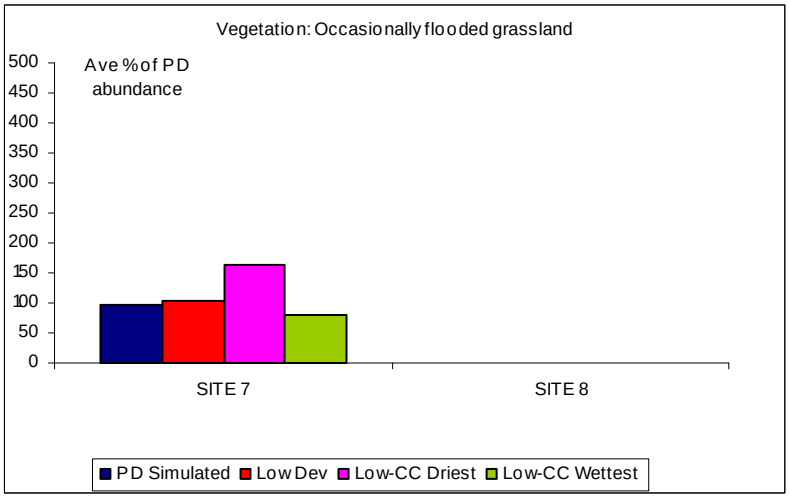


Site 8: Boteti River



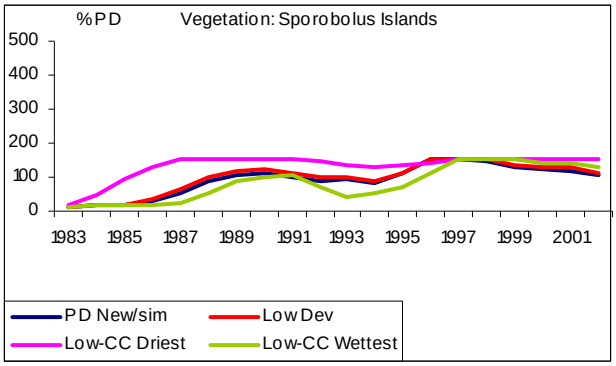
Summary change per scenario

Can be turned into savanna in long, dry periods.

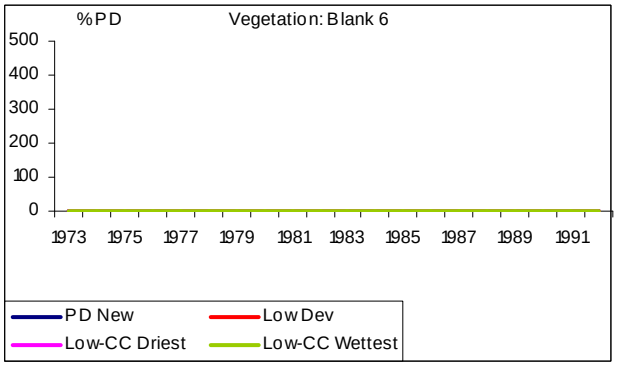


3.3.16 Sporobolus Islands

Site 7: Okavango River @ Xakanaxa

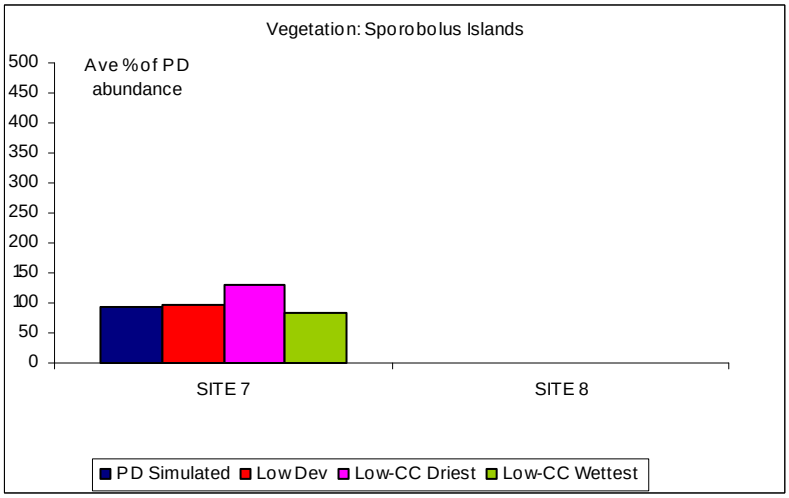


Site 8: Boteti River



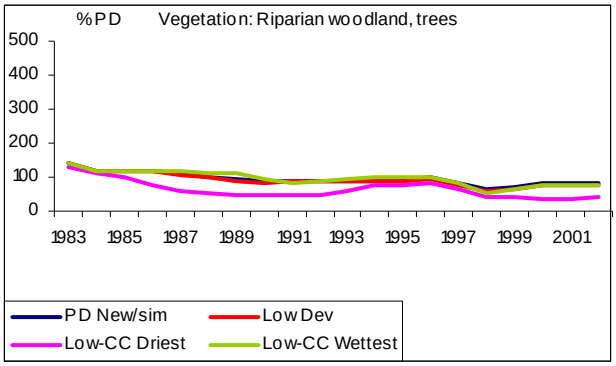
Summary change per scenario

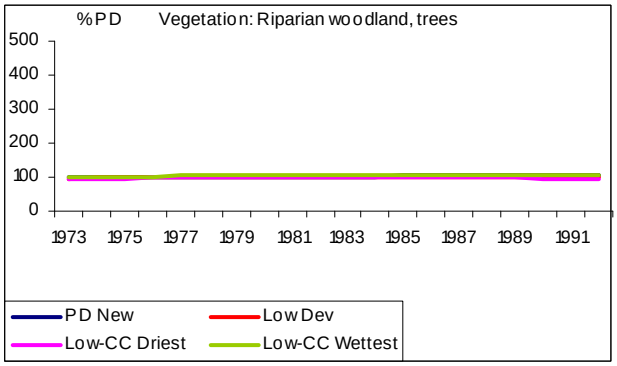
They are confined to very elevated areas, and there is a maximum to which they can increase.



3.3.17 Riparian woodland, trees

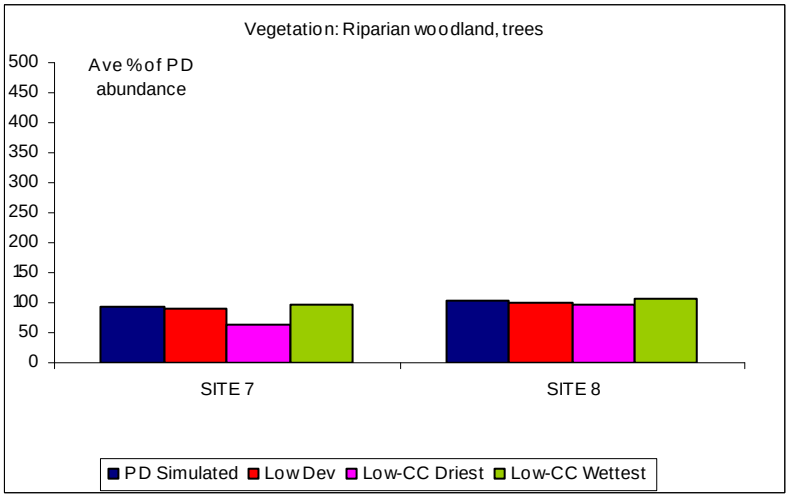
Site 7: Okavango River @ XakanaxaSite 8: Boteti River





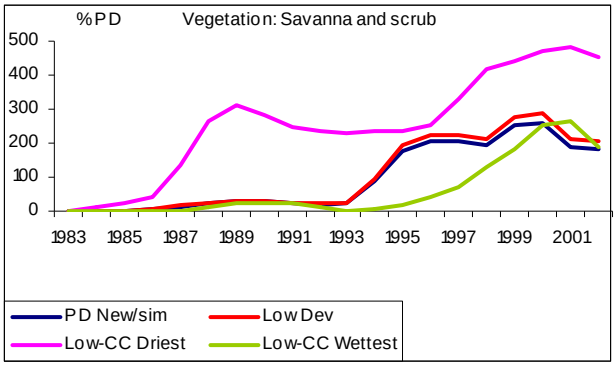
Summary change per scenario

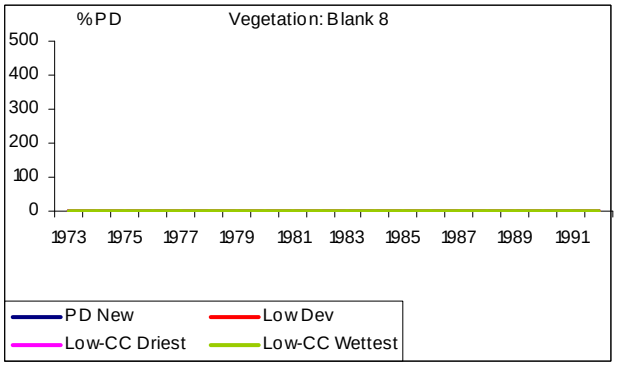
Old trees which will not respond immediately to changes in flows, but will gradually decline in successive dry years if groundwater table drops.



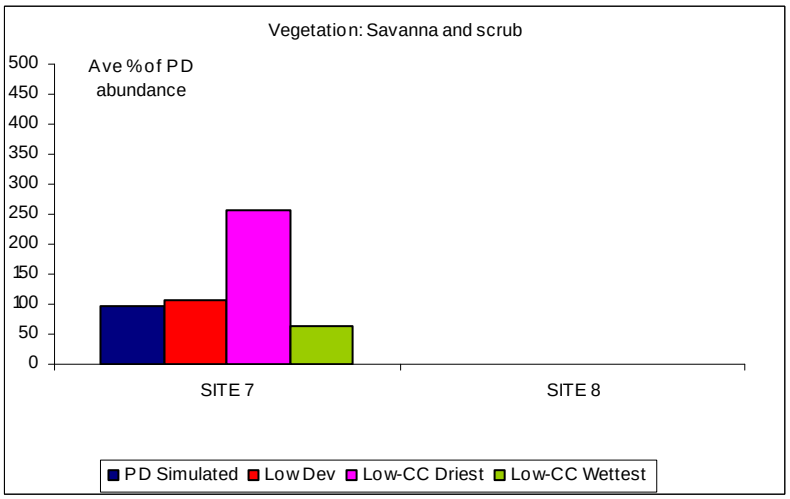
3.3.18 Savanna and scrub

Site 7: Okavango River @ XakanaxaSite 8: Boteti River



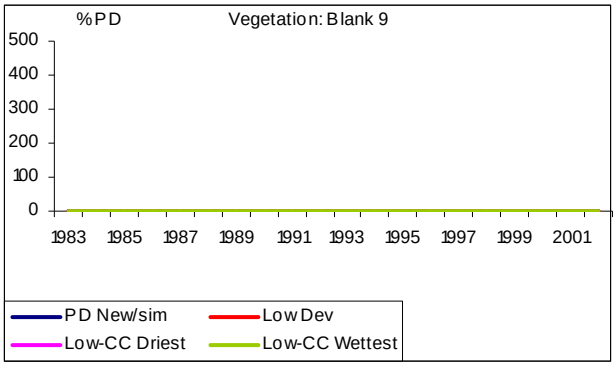


Summary change per scenario
Will increase in dry conditions and can encroach on other wetter habitats.

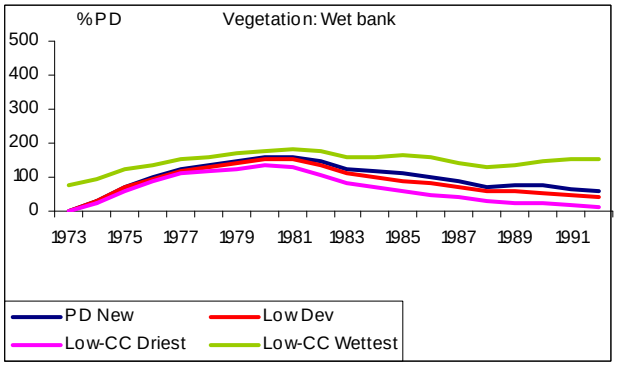


3.3.19 Wet bank

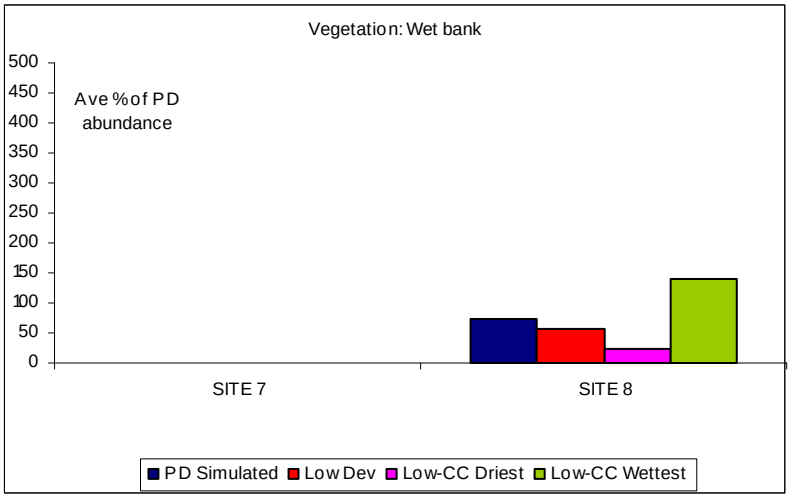
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.4. Macroinvertebrates

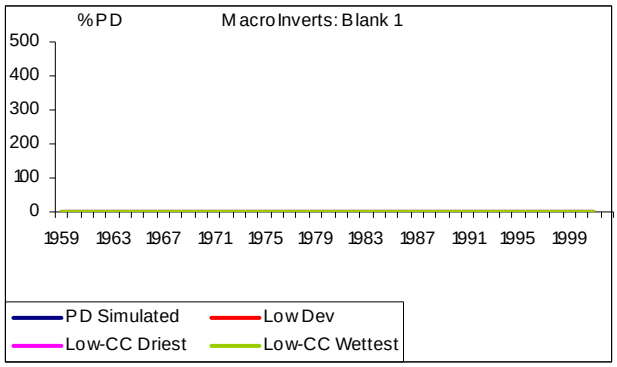
This section provides the time-series for aquatic macroinvertebrate indicators under the flow regime resulting from the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Channel-submerged vegetation
- Channel-marginal vegetation
- Channel-fine sediments
- Channel-cobbles, boulders
- Channel rapid, fast flowing
- Channel-pools
- Floodplain-marginal vegetation
- Floodplain-pools, backwaters
- Mopane woodland-pools.

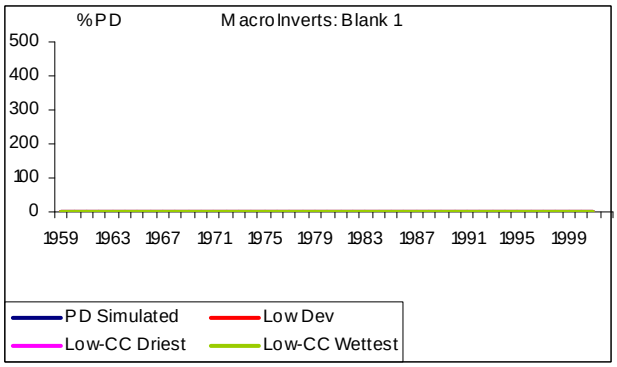
3.4.1 Channel-submerged vegetation

(Channel dwellers in submerged vegetation)- Crustacea (Freshwater shrimps)

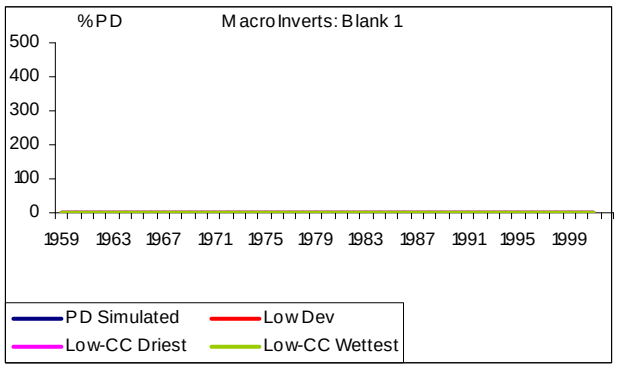
Site 1: Cubango River @ Capico



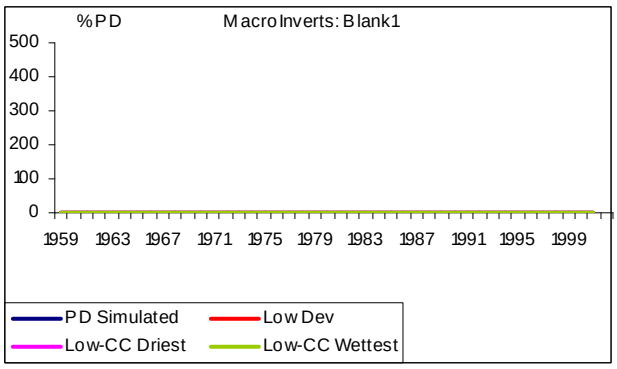
Site 2: Cubango River @ Mucundi



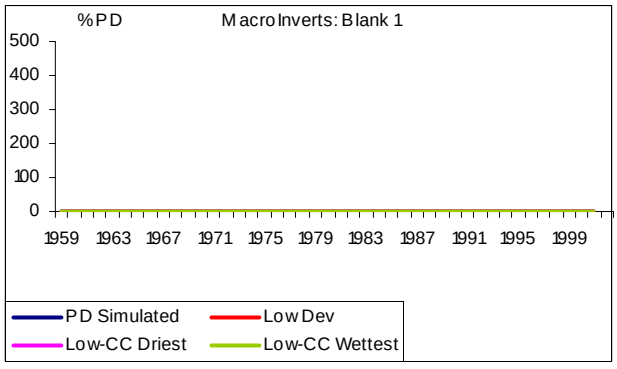
Site 3: Cuito River @ Cuito Cuanavale



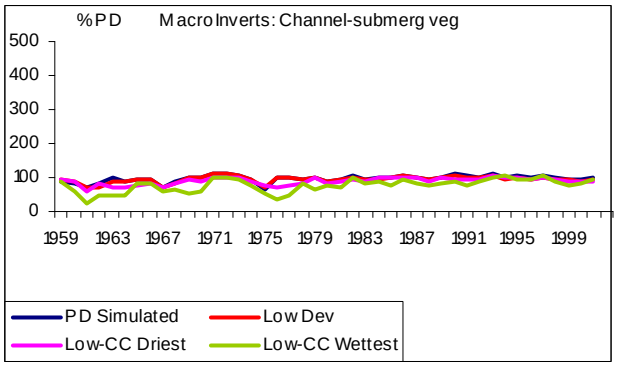
Site 4: Okavango River @ Rundu



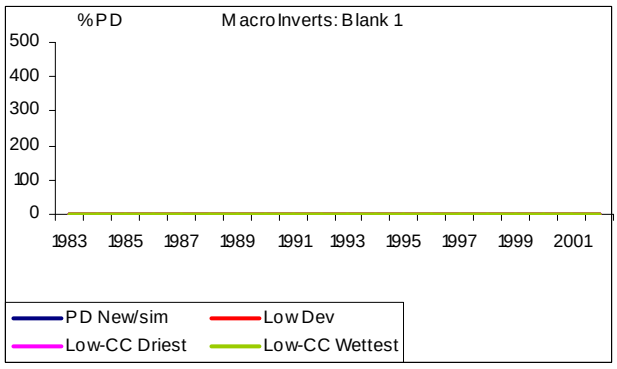
Site 5: Okavango River @ Popa Falls



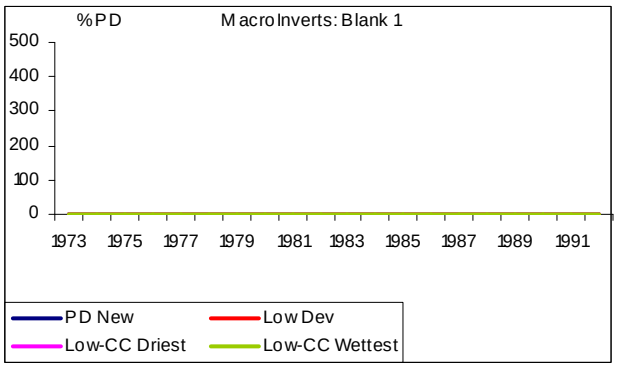
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

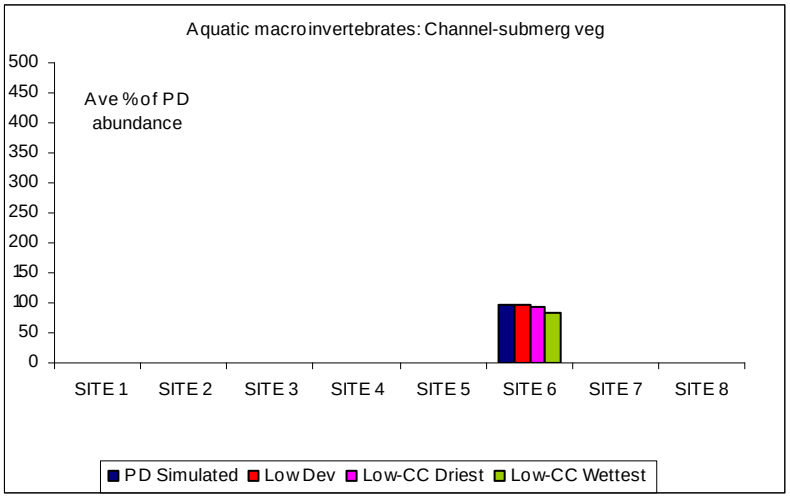


Site 8: Boteti River



Summary change per scenario

Water must always be present. At minimum flow habitat will be greatly reduced leading to population decline as predation increases.



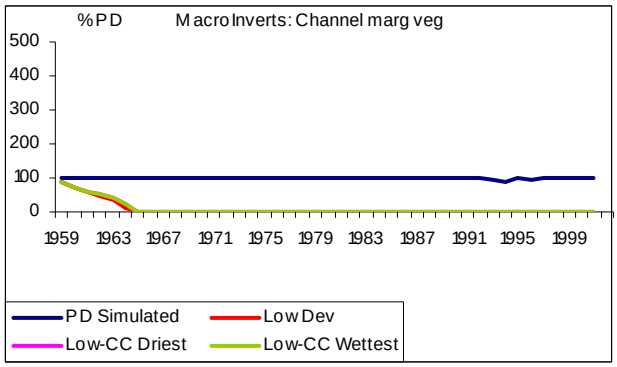
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

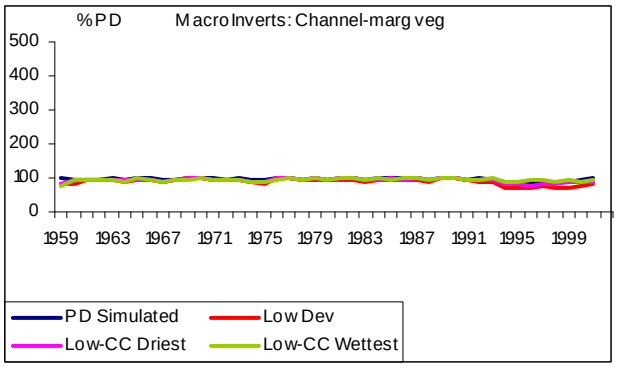
3.4.2 Channel-marginal vegetation

(Channel dwellers in marginal vegetation)- Caenidae, Tricorythidae

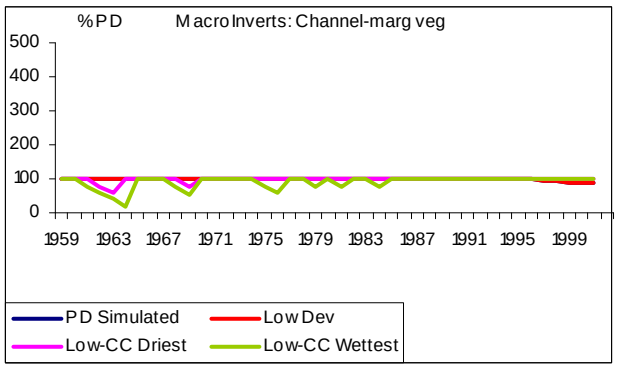
Site 1: Cubango River @ Capico



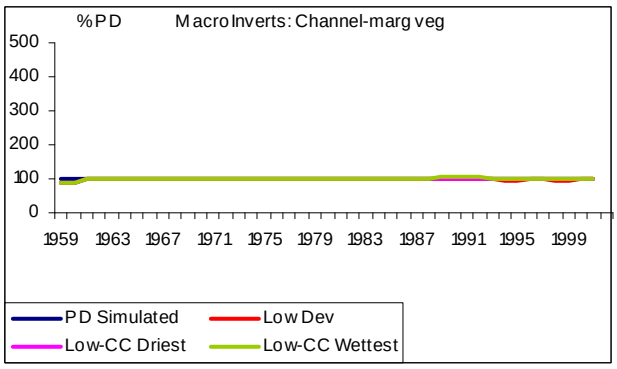
Site 2: Cubango River @ Mucundi



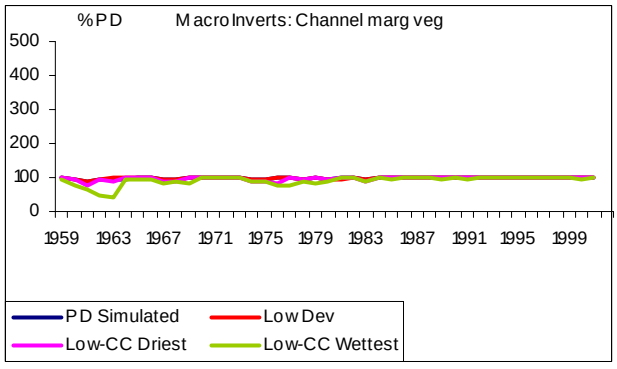
Site 3: Cuito River @ Cuito Cuanavale



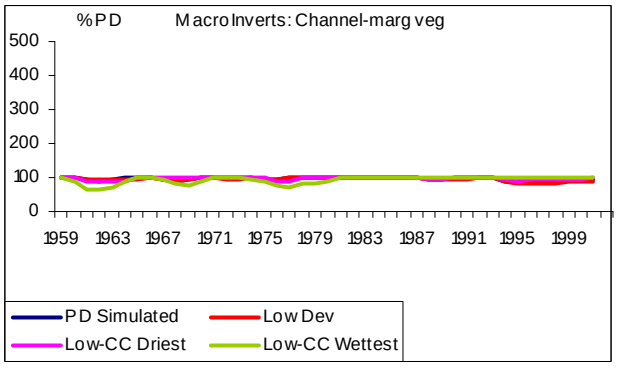
Site 4: Okavango River @ Rundu



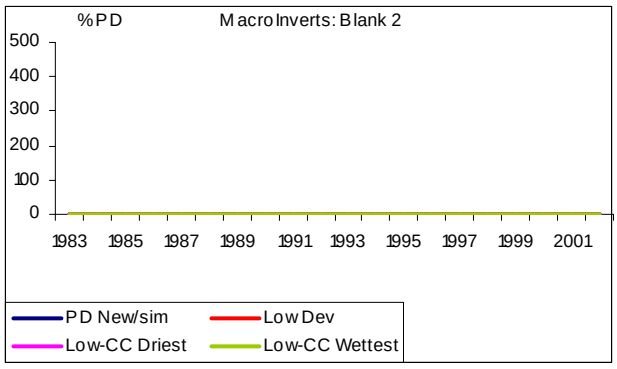
Site 5: Okavango River @ Popa Falls



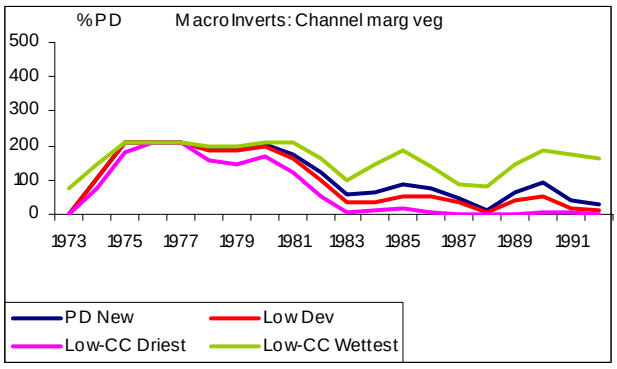
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

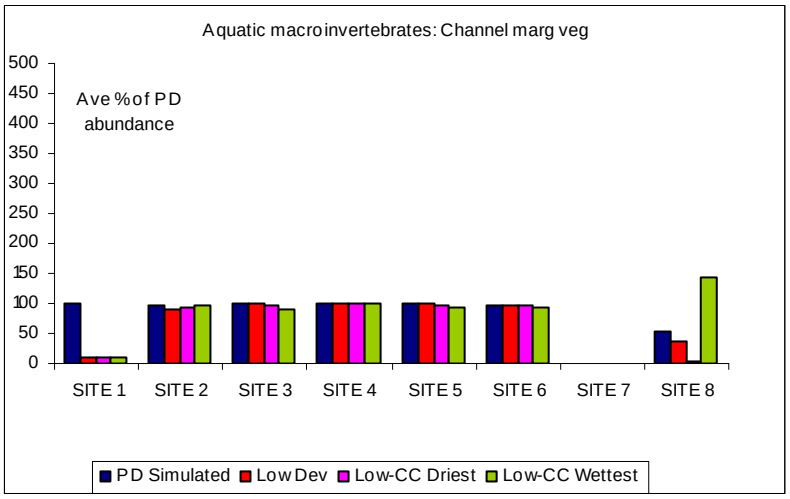


Site 8: Boteti River



Summary change per scenario

Water must always be present. High, long-duration flooding may lead to destruction of habitat and reduction in abundance. Long duration of minimum flows restricted to the river bed may also lead to loss of habitat.



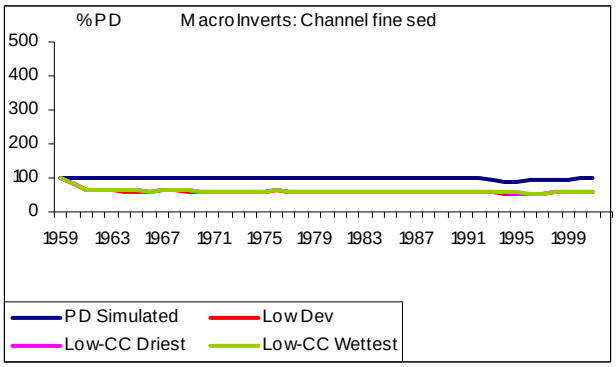
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

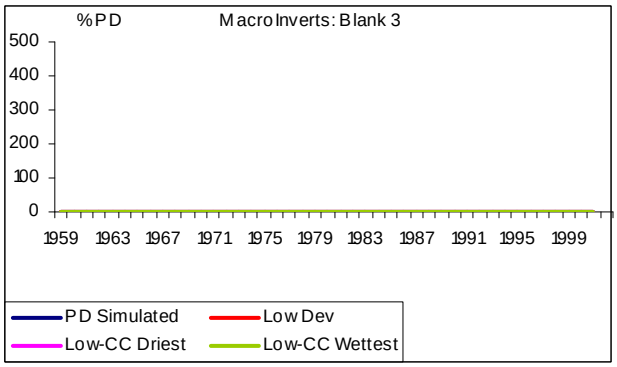
3.4.3 Channel-fine sediment

(Channel dwellers in fine sediment)- Unionidae, Sphaeridae

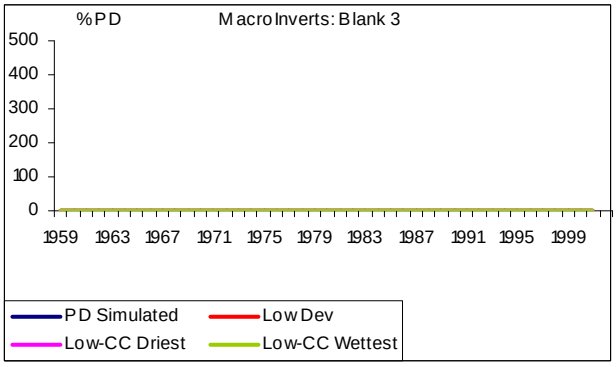
Site 1: Cubango River @ Capico



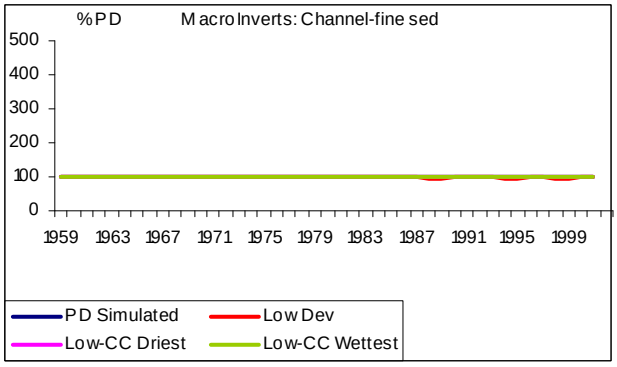
Site 2: Cubango River @ Mucundi



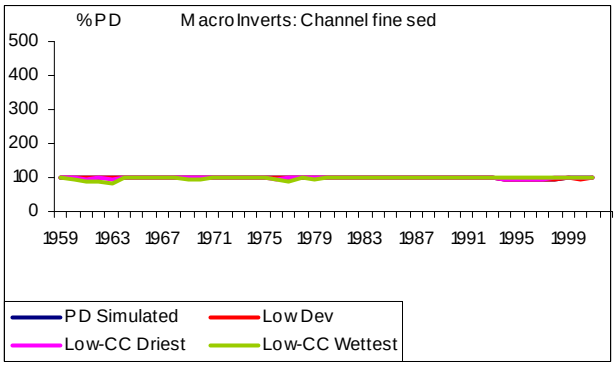
Site 3: Cuito River @ Cuito Cuanavale



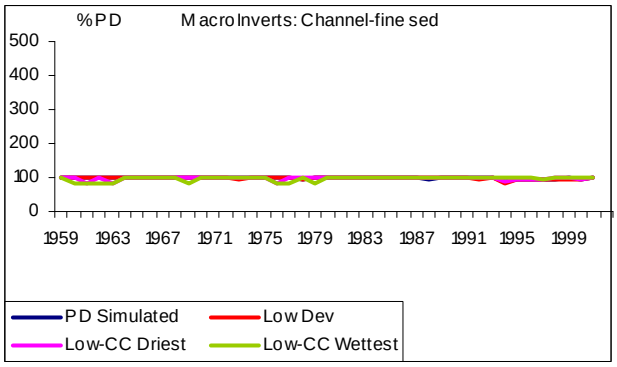
Site 4: Okavango River @ Rundu



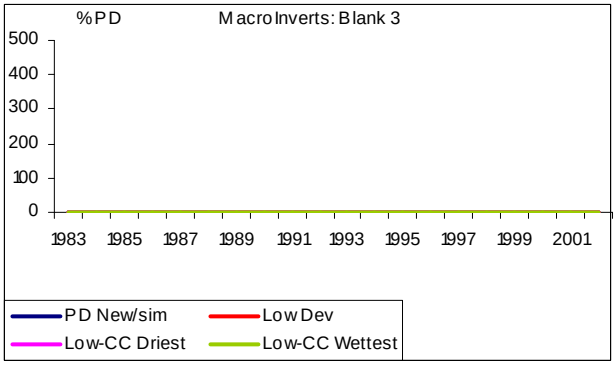
Site 5: Okavango River @ Popa Falls



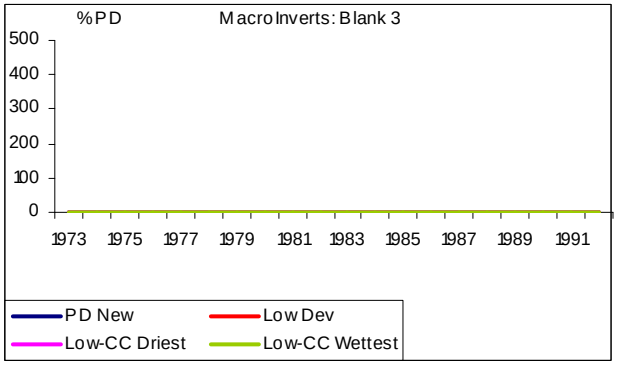
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

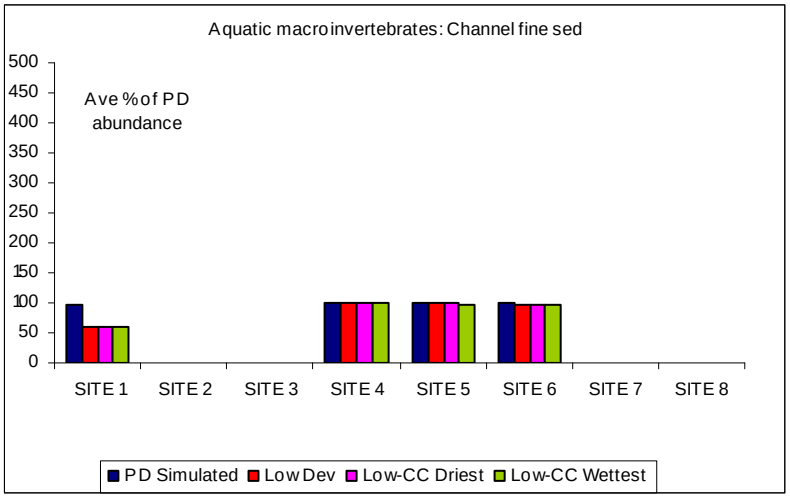


Site 8: Boteti River



Summary change per scenario

Will normally survive as long as there is some water covering the sediment. Long dry spells will reduce abundance or even eliminate these indicators.



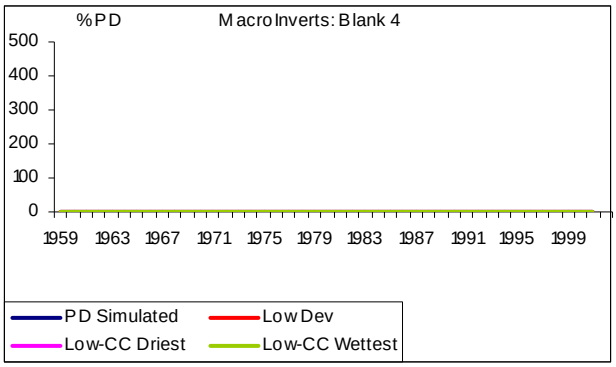
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

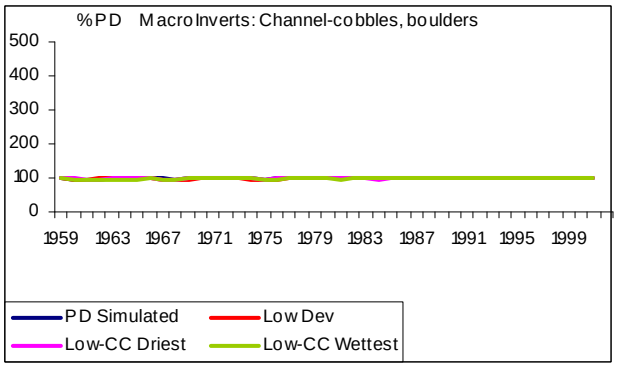
3.4.4 Channel-cobbles, boulders

(Channel dwellers in stones and rocks)- Hydropsychidae, Ecnomidae

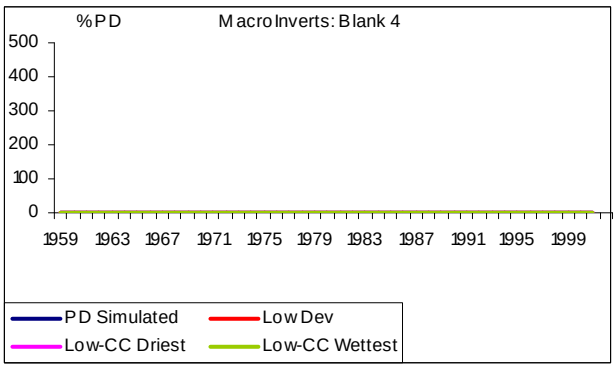
Site 1: Cubango River @ Capico



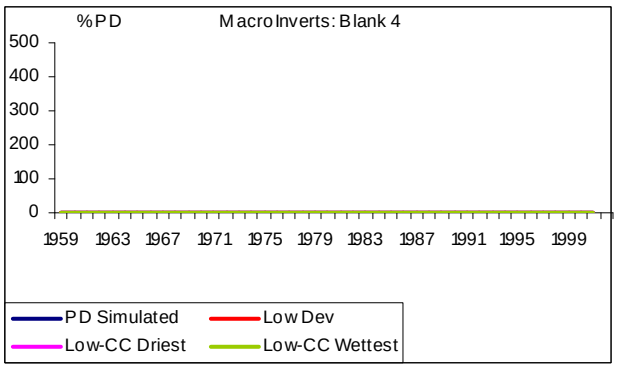
Site 2: Cubango River @ Mucundi



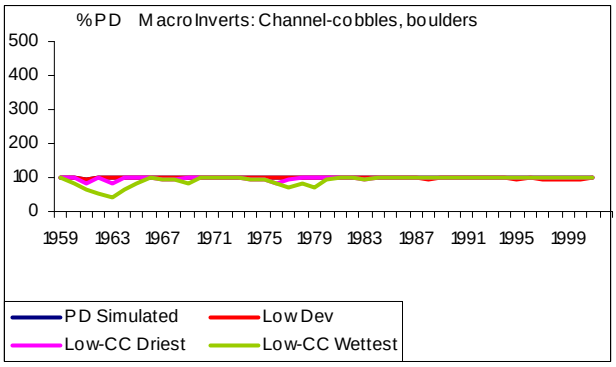
Site 3: Cuito River @ Cuito Cuanavale



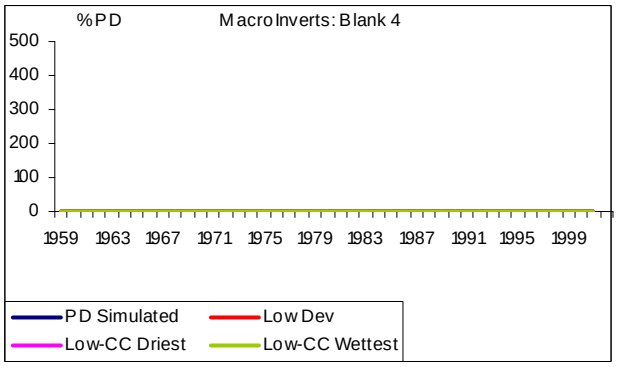
Site 4: Okavango River @ Rundu



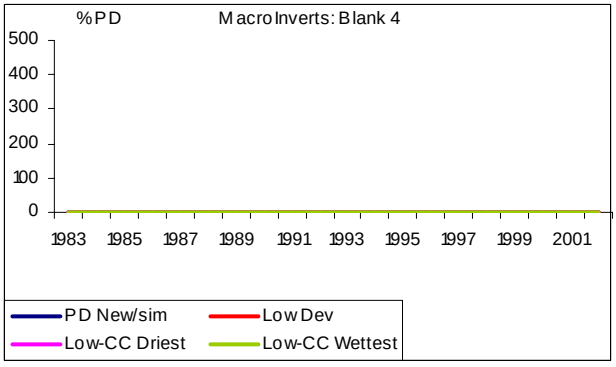
Site 5: Okavango River @ Popa Falls



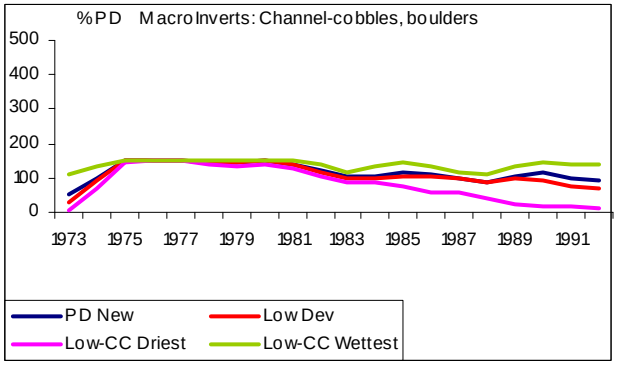
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

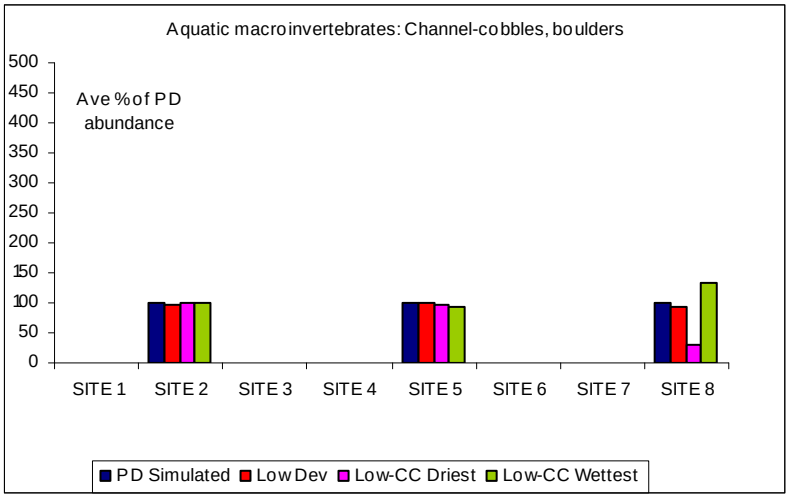


Site 8: Boteti River



Summary change per scenario

Water must always be present. These indicators will reduce and may disappear if exposed to long duration of minimum flows leading to drying of rocks.



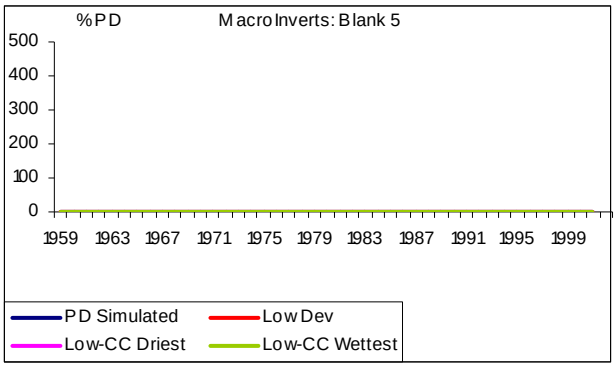
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

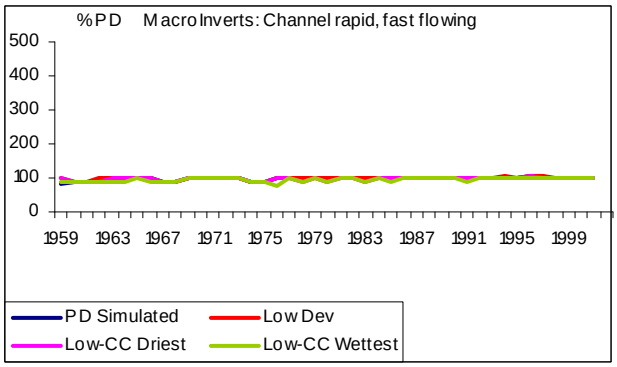
3.4.5 Channel rapid, fast flowing

(Channel dwellers in rapids or fast flowing waters)- Simuliidae, Hydropsychidae

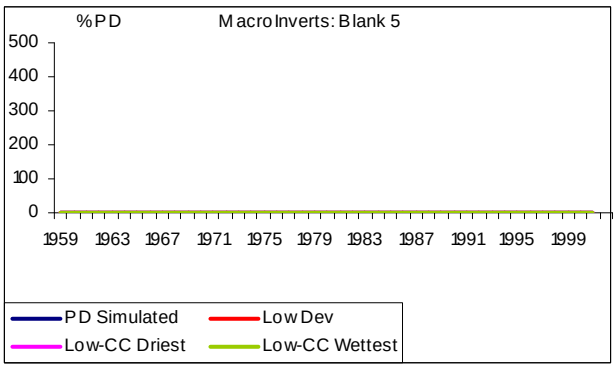
Site 1: Cubango River @ Capico



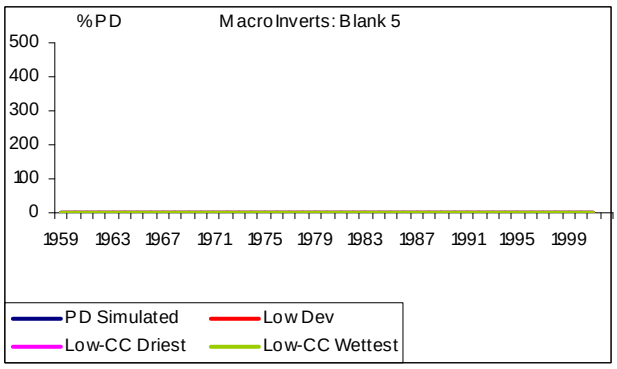
Site 2: Cubango River @ Mucundi



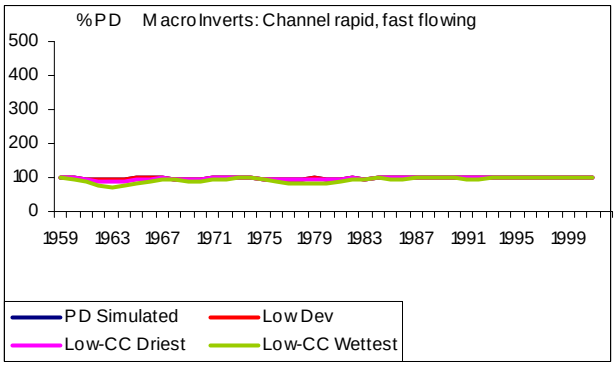
Site 3: Cuito River @ Cuito Cuanavale



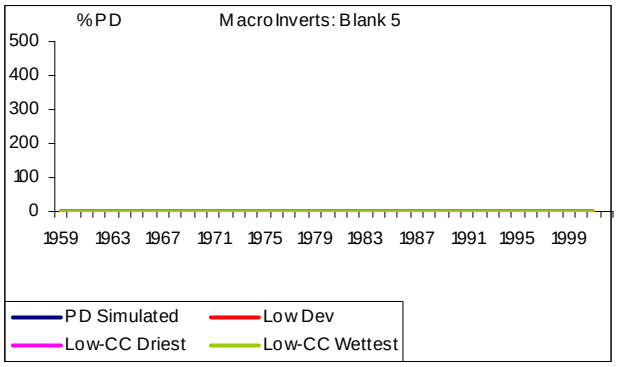
Site 4: Okavango River @ Rundu



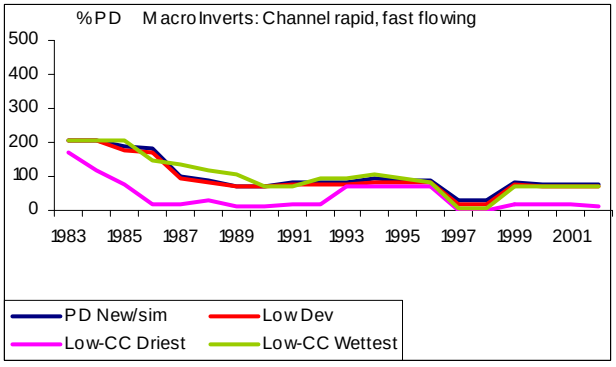
Site 5: Okavango River @ Popa Falls



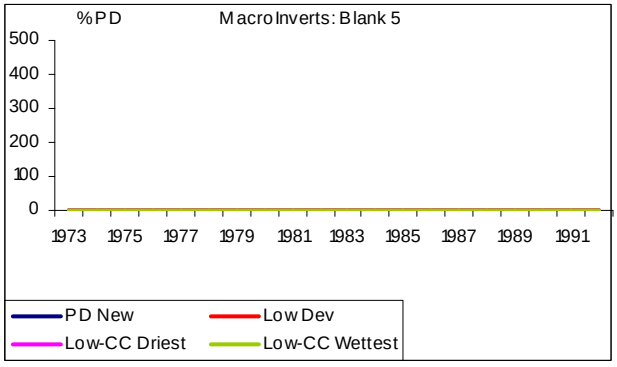
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

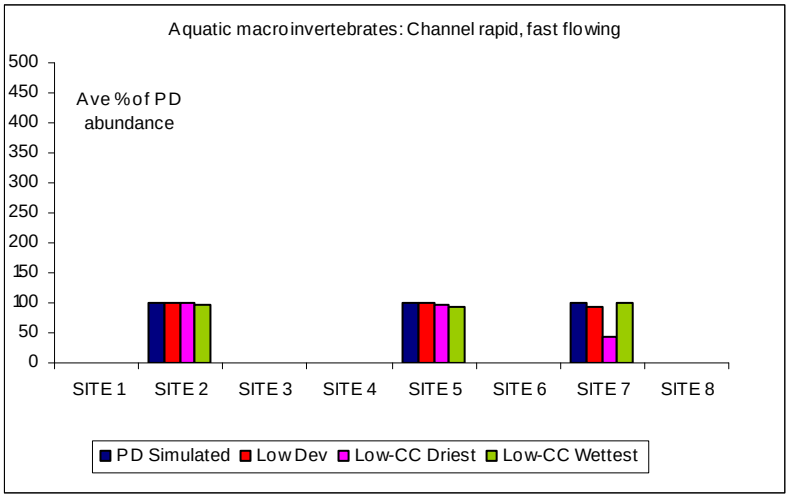


Site 8: Boteti River



Summary change per scenario

Water must always be present. These indicators will reduce and may disappear if exposed to long duration of minimum flows leading to drying of river bed.



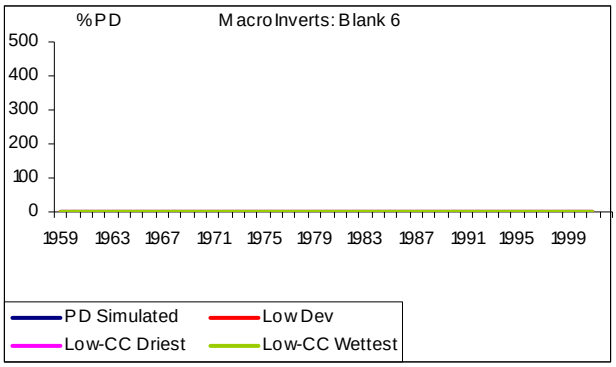
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

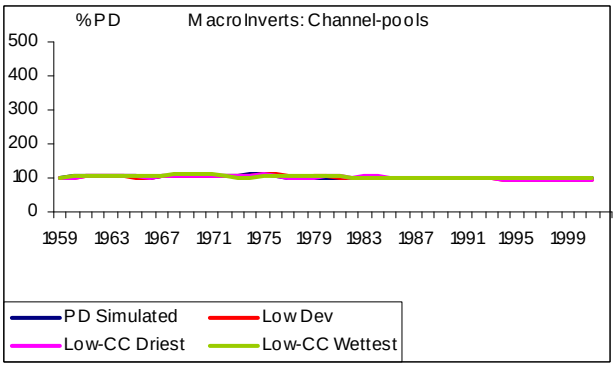
3.4.6 Channel-pools

(hollows formed in the bedrock)- Dytiscidae

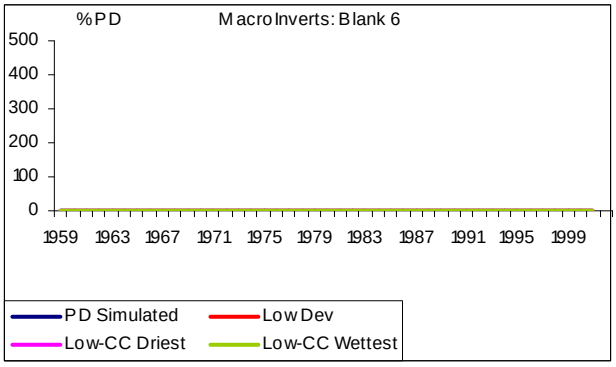
Site 1: Cubango River @ Capico



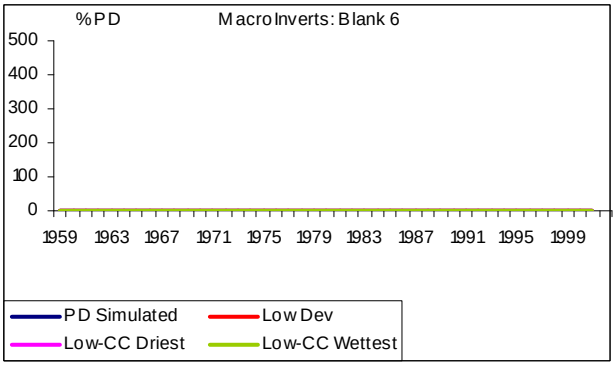
Site 2: Cubango River @ Mucundi



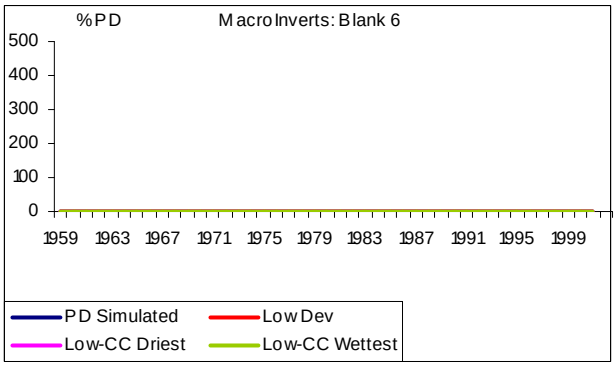
Site 3: Cuito River @ Cuito Cuanavale



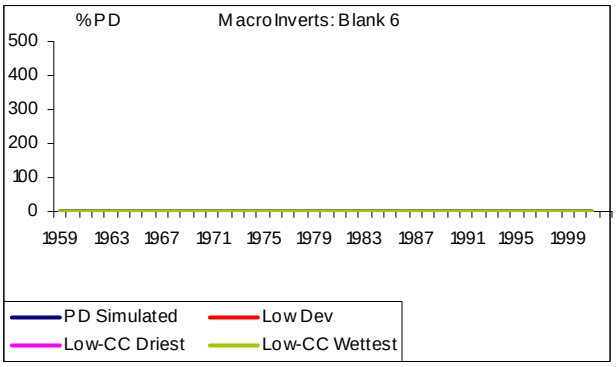
Site 4: Okavango River @ Rundu



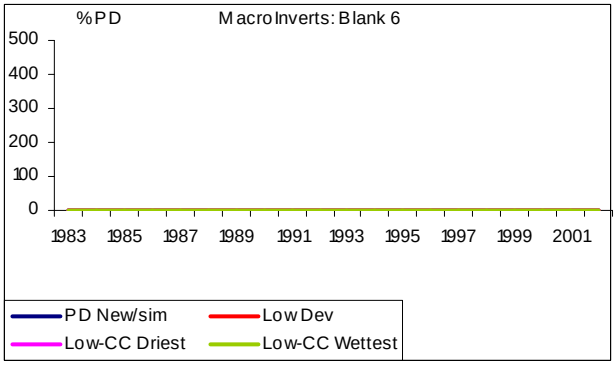
Site 5: Okavango River @ Popa Falls



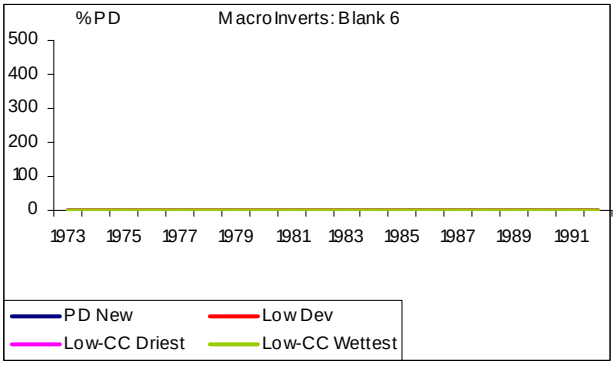
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

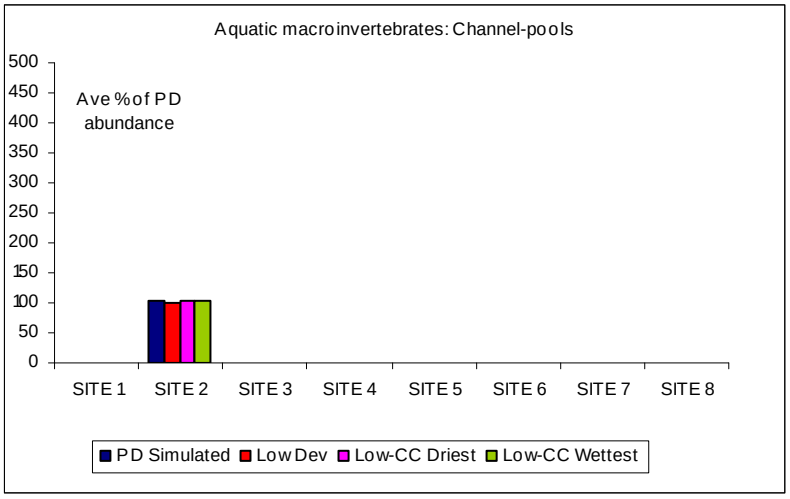


Site 8: Boteti River



Summary change per scenario

Water must always be present. High, long-duration flooding will destroy this habitat while long duration of minimum flows may lead to drying out of the pools also destroying the pools.



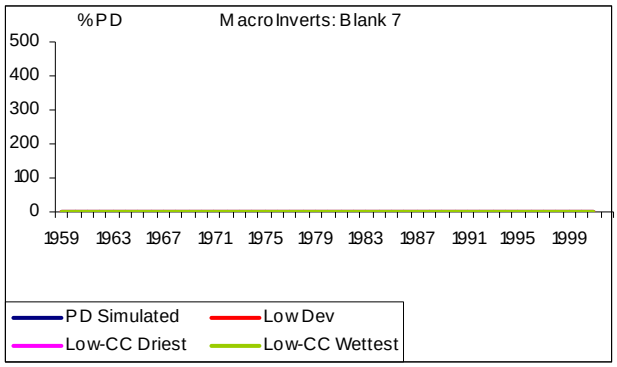
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

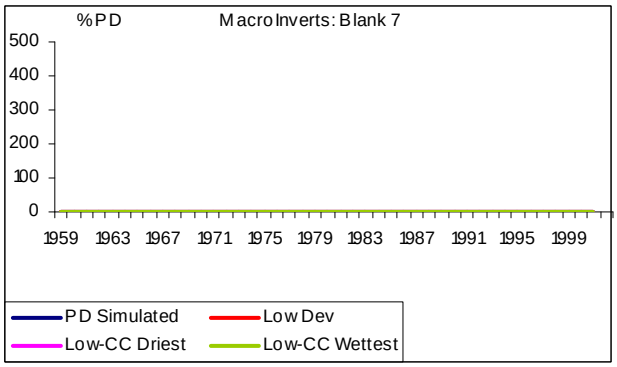
3.4.7 Floodplain-marginal vegetation

(Floodplain dwellers in marginal vegetation)- Coenagrionidae, Physidae, Planorbidae

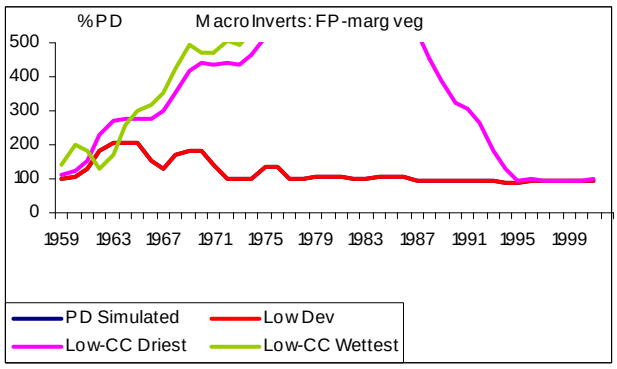
Site 1: Cubango River @ Capico



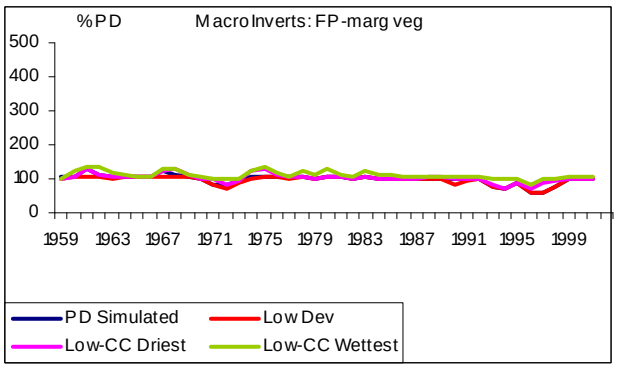
Site 2: Cubango River @ Mucundi



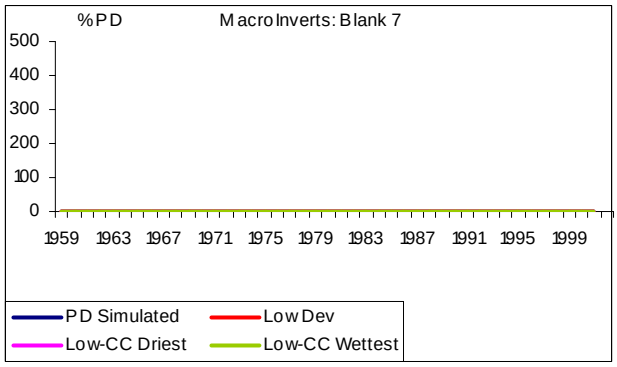
Site 3: Cuito River @ Cuito Cuanavale



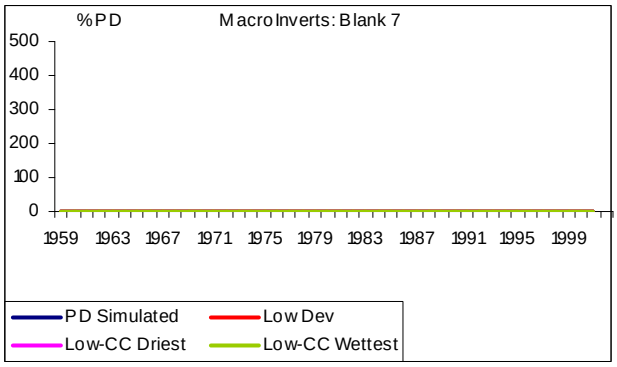
Site 4: Okavango River @ Rundu



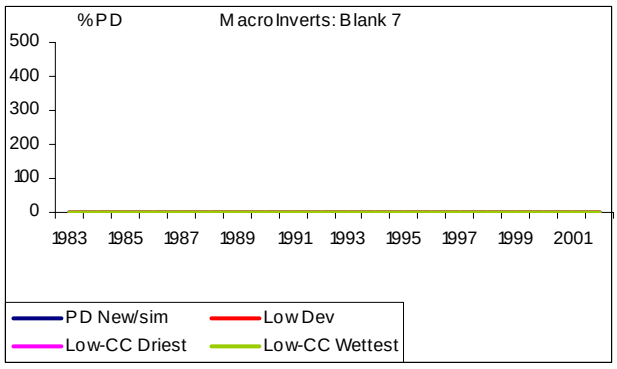
Site 5: Okavango River @ Popa Falls



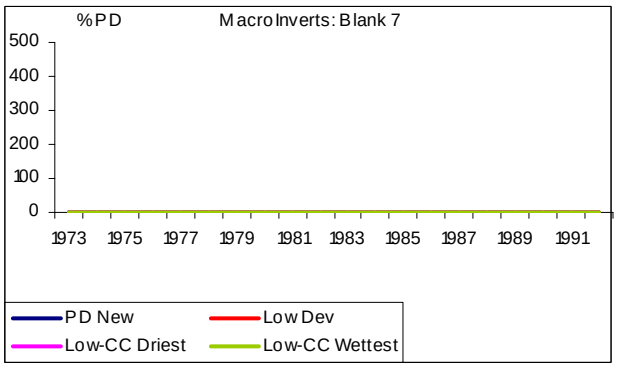
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

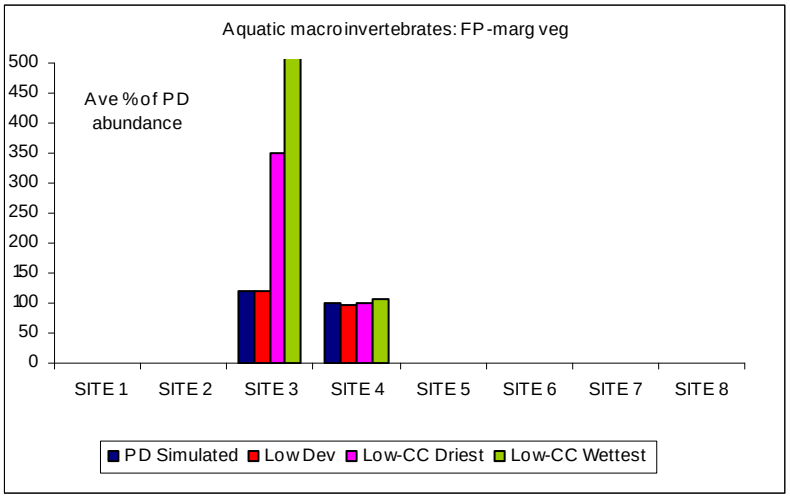


Site 8: Boteti River



Summary change per scenario

Drying out of floodplains consequent to prolonged low flows will reduce or eradicate this habitat.



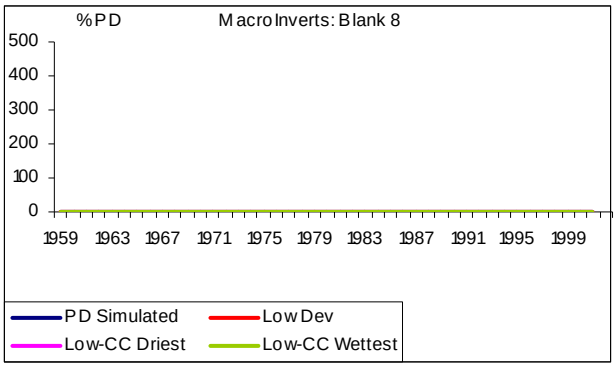
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

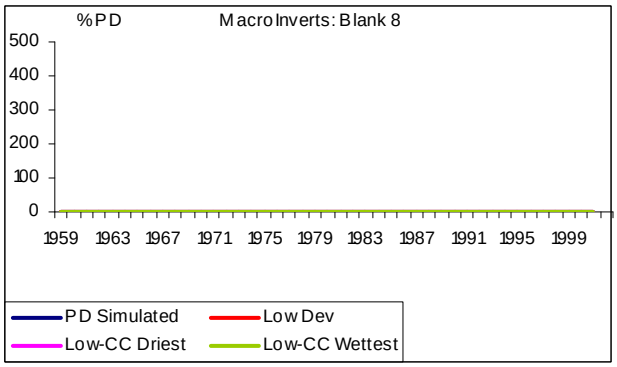
3.4.8 Floodplain pools, backwaters

(Dwellers in seasonal floodplain backwaters)- Dytiscidae

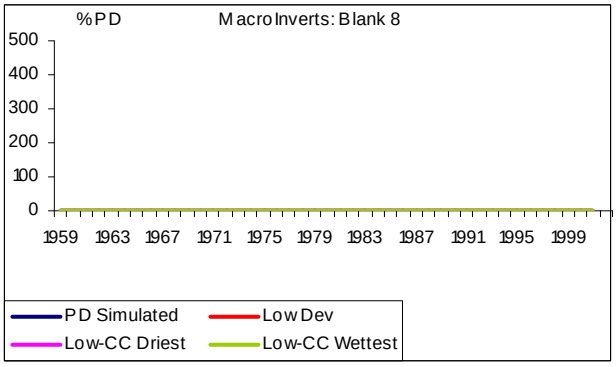
Site 1: Cubango River @ Capico



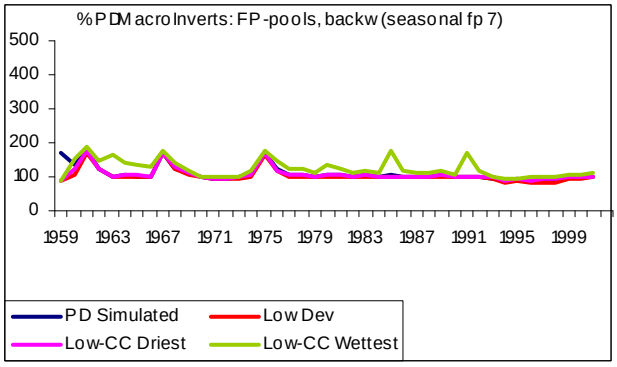
Site 2: Cubango River @ Mucundi



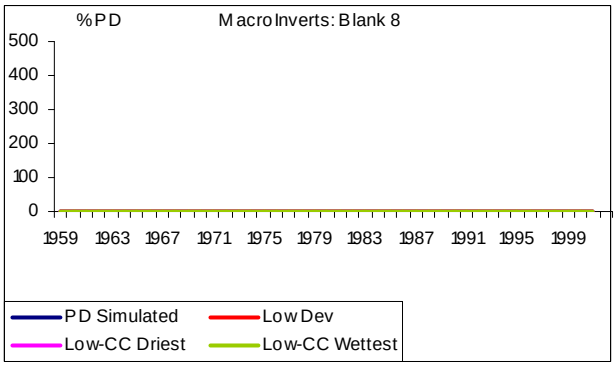
Site 3: Cuito River @ Cuito Cuanavale



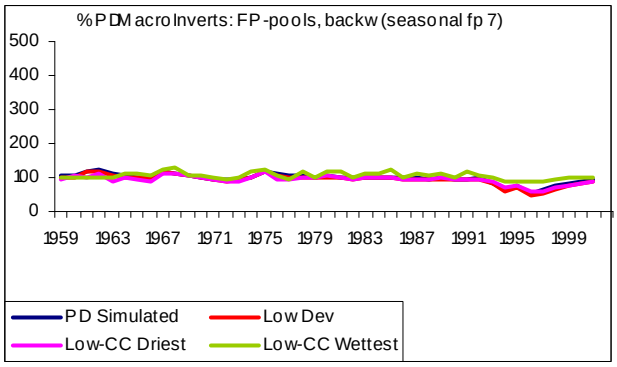
Site 4: Okavango River @ Rundu



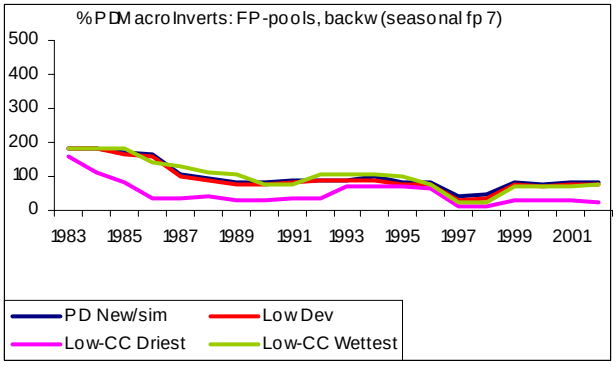
Site 5: Okavango River @ Popa Falls



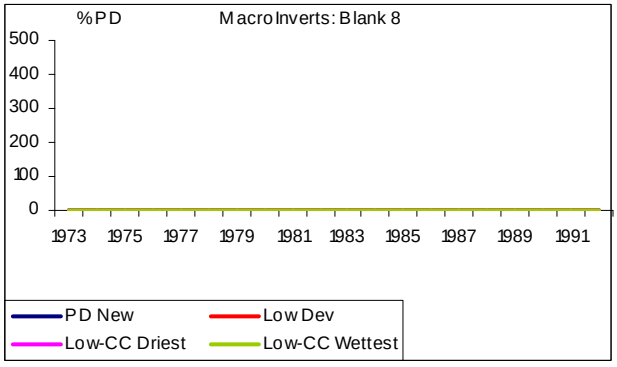
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

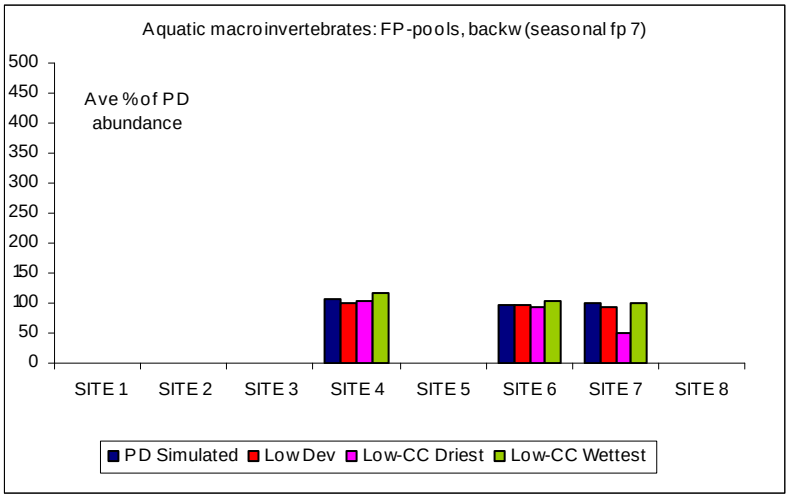


Site 8: Boteti River



Summary change per scenario

Drying out of floodplains consequent to prolonged low flows will reduce or eradicate this habitat.



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.5. Fish

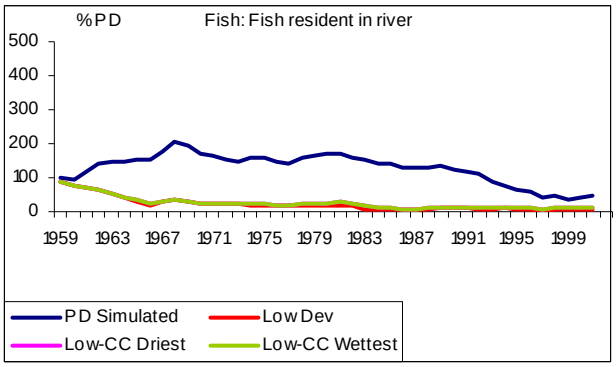
This section provides the time-series for fish indicators under the flow regime resulting from the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Fish resident in river
- Migrate floodplain small fish
- Migrate floodplain large fish
- Fish-sandbank dweller
- Fish-rock dweller
- Fish-marginal vegetation
- Fish in backwaters.

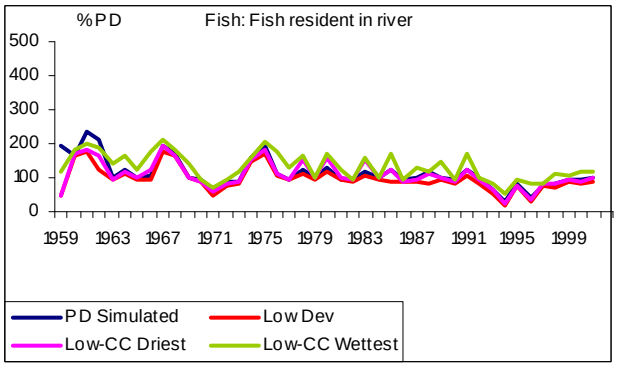
3.5.1 Fish resident in river

(Living in main channels, undertake longitudinal migrations.)- Spend most time in main channel in deep water but use floodplain. Example Tigerfish [Hydrocynus vittatus].

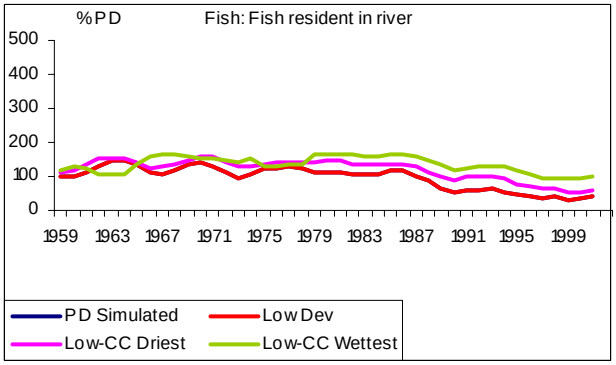
Site 1: Cubango River @ Capico



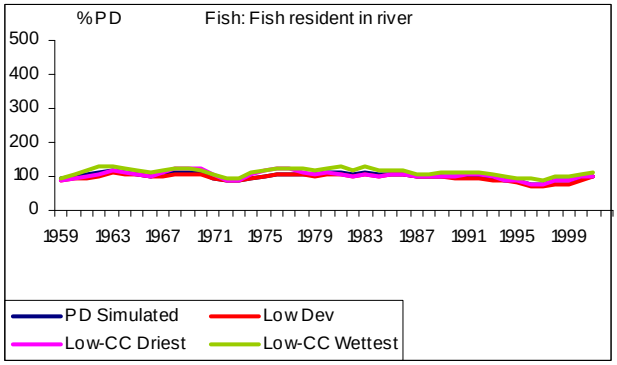
Site 2: Cubango River @ Mucundi



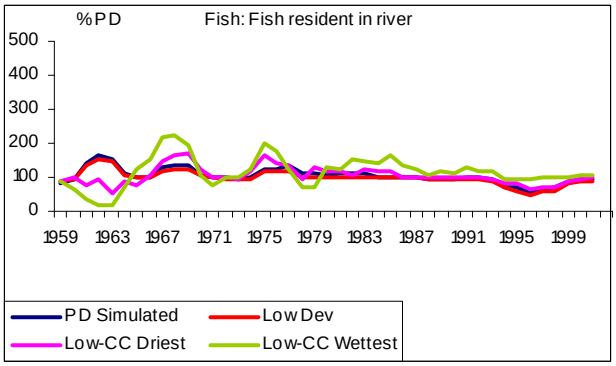
Site 3: Cuito River @ Cuito Cuanavale



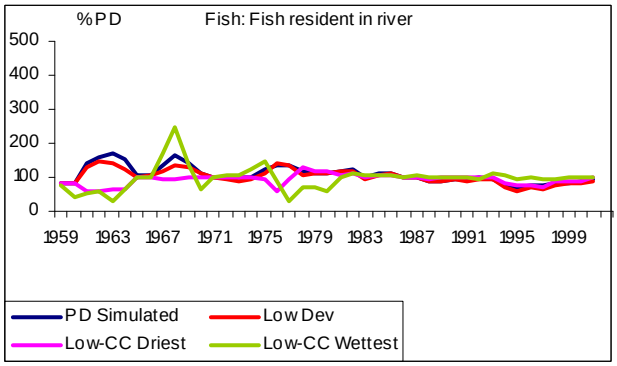
Site 4: Okavango River @ Rundu



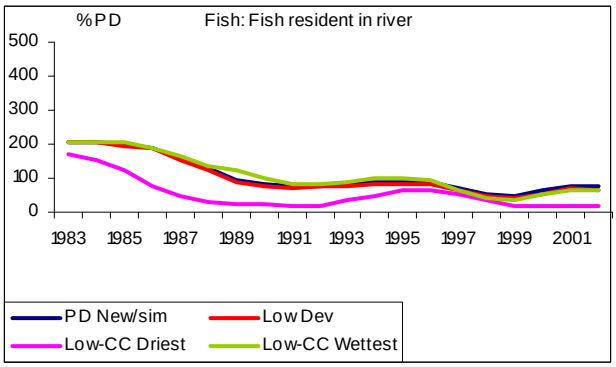
Site 5: Okavango River @ Popa Falls



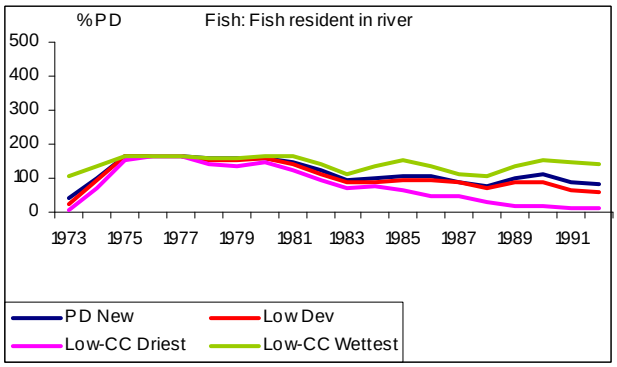
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

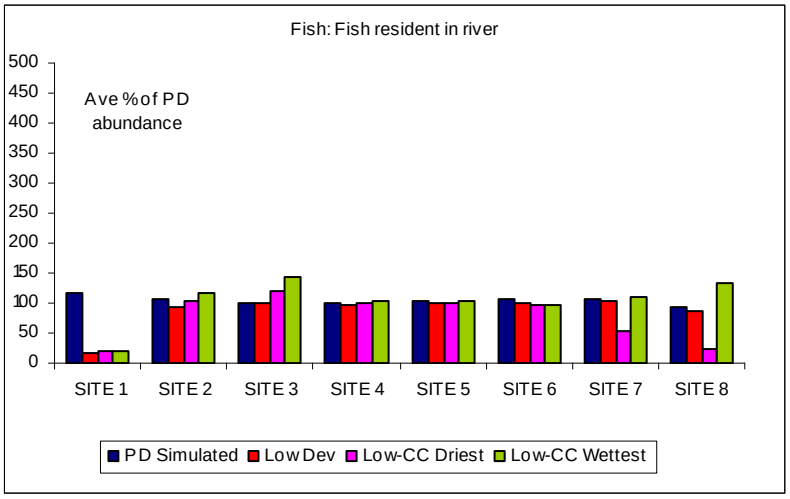


Site 8: Boteti River



Summary change per scenario

Require clear deep, running water and pools throughout the hydrological cycle.



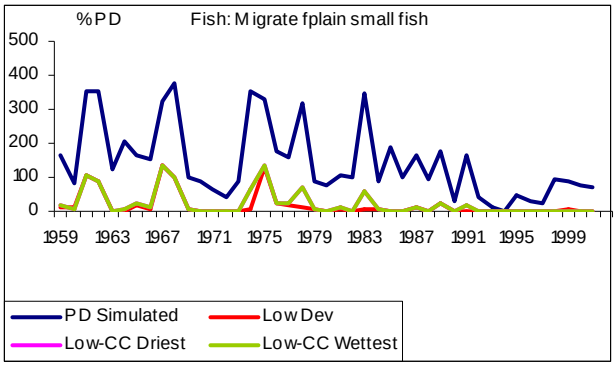
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

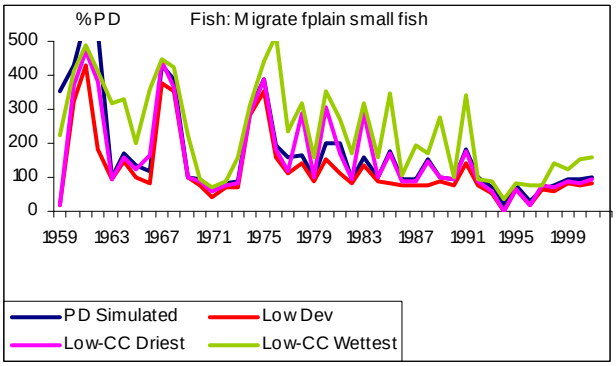
3.5.2 Migrate floodplain - small fish

(Resident in river, migrate into floodplains for feeding, breeding and protection against predation.)- Small species dependent on lateral migration to floodplains for breeding and feeding. Example Bulldog [Marcusenius macrolepidotus].

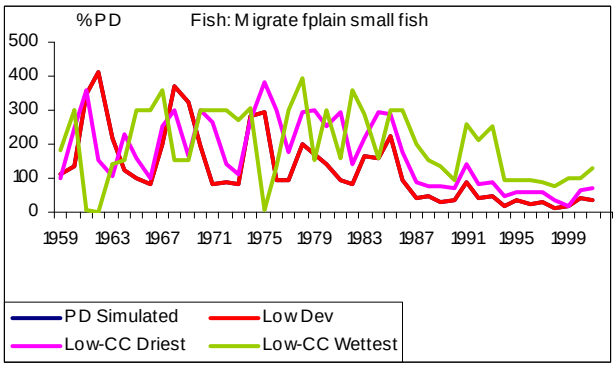
Site 1: Cubango River @ Capico



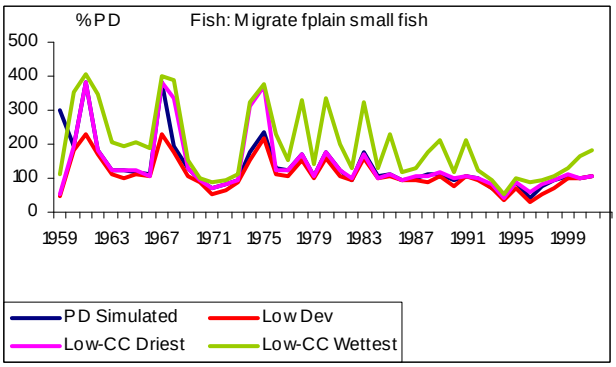
Site 2: Cubango River @ Mucundi



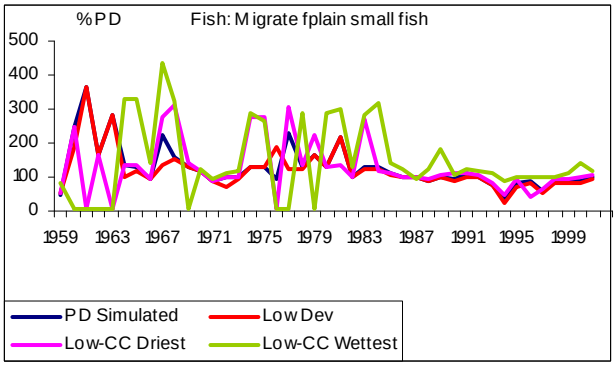
Site 3: Cuito River @ Cuito Cuanavale



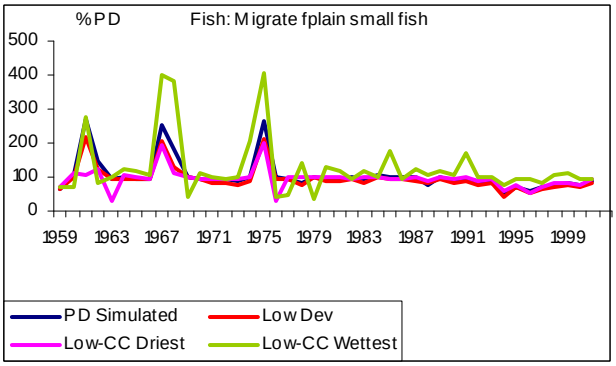
Site 4: Okavango River @ Rundu



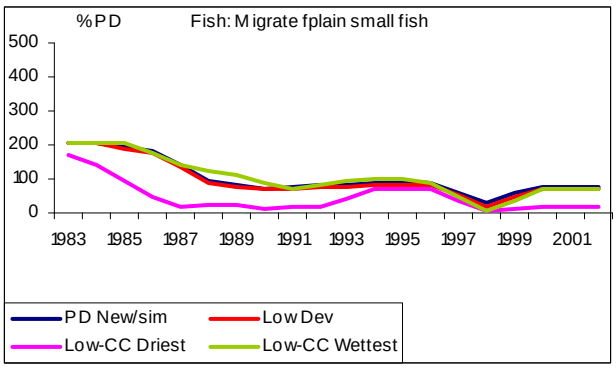
Site 5: Okavango River @ Popa Falls



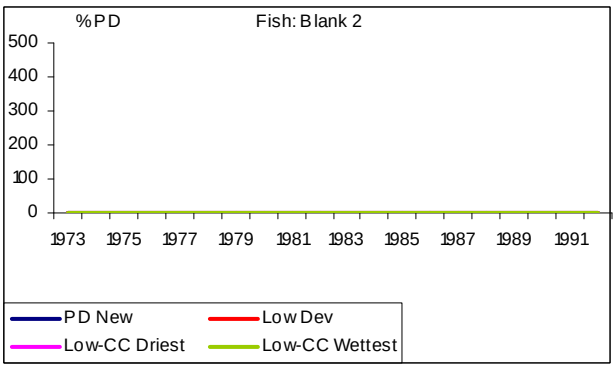
Site 6: Okavango River @ Pan Handle



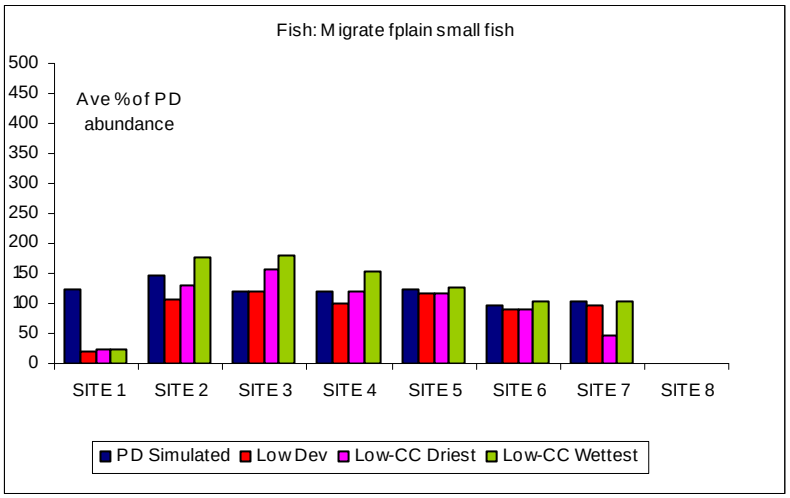
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Depend on regular flooding of shallow vegetated floodplains and deeper [>50cm] refuges during low flow conditions.

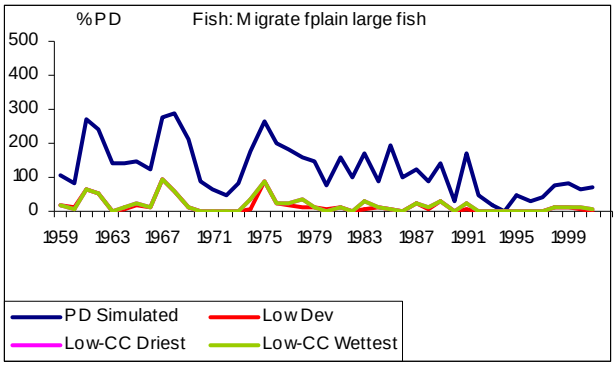


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

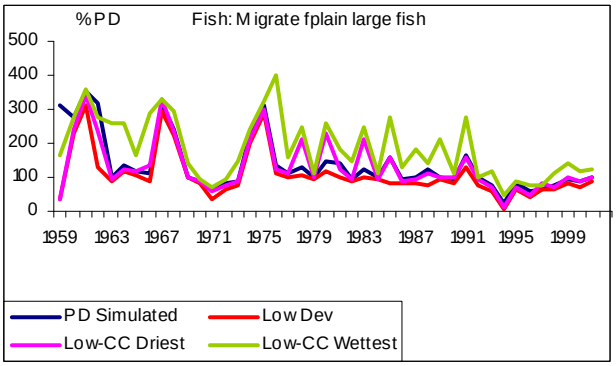
3.5.3 Migrate floodplain - large fish

(Resident in river, migrate into floodplains for feeding, breeding and protection against predation.)- Large species dependent on lateral migration to floodplains for breeding and feeding. Example Redbreast tilapia [Tilapia rendalli].

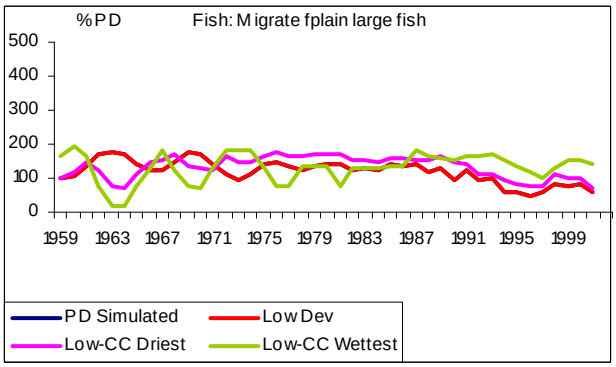
Site 1: Cubango River @ Capico



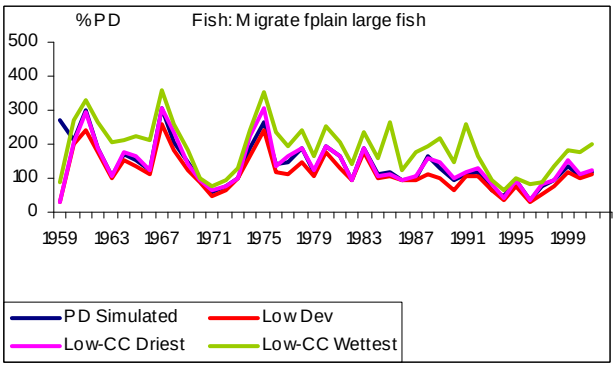
Site 2: Cubango River @ Mucundi



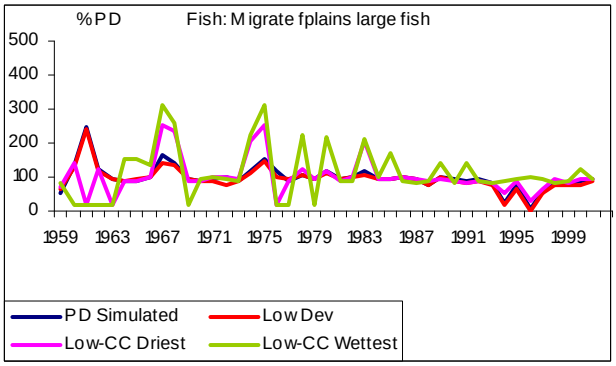
Site 3: Cuito River @ Cuito Cuanavale



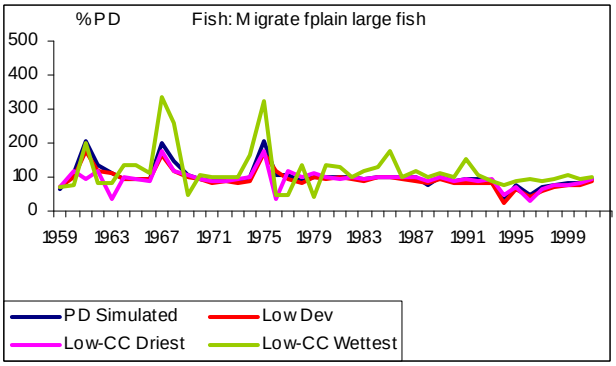
Site 4: Okavango River @ Rundu



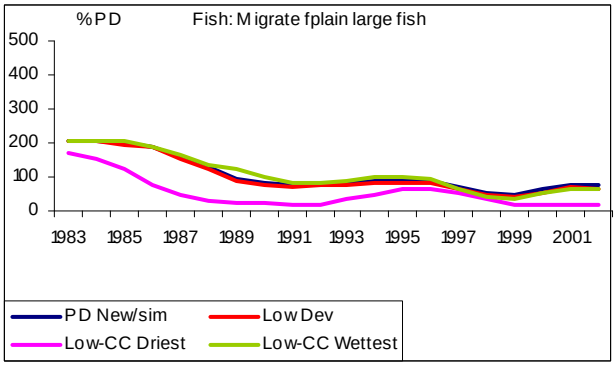
Site 5: Okavango River @ Popa Falls



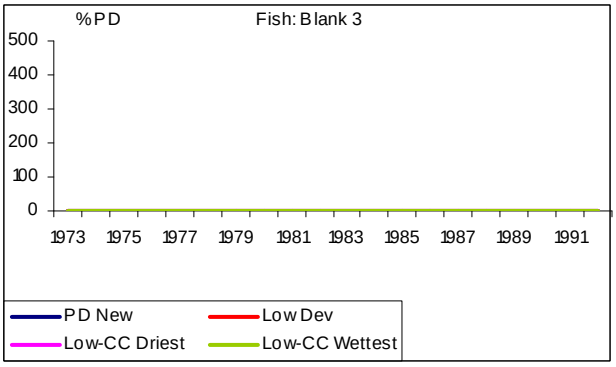
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

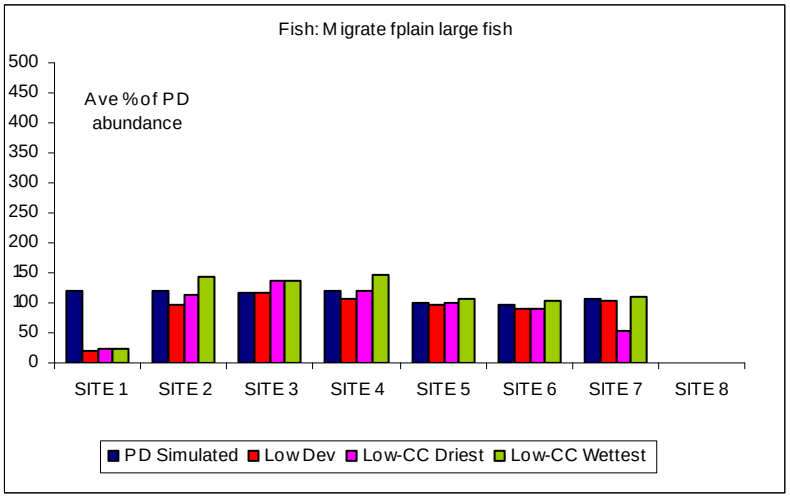


Site 8: Boteti River



Summary change per scenario

Depend on regular flooding of shallow vegetated floodplains and deeper [>200cm] refuges during low flow conditions.



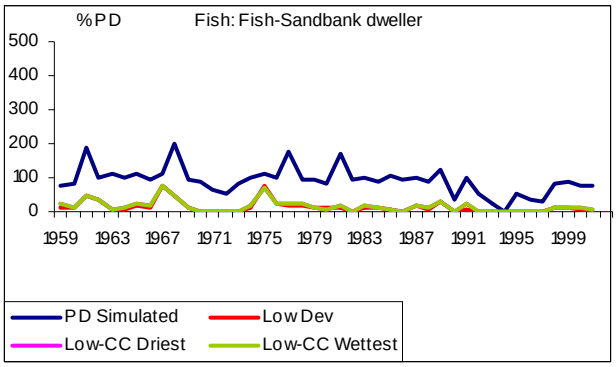
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

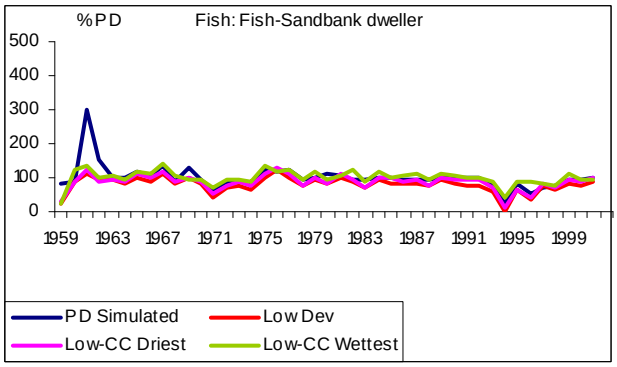
3.5.4 Fish-Sandbank dweller

(Species living on sandbanks and habitats with sandy bottoms.)- Fish species living mainly on the actively moving sandbanks or a sandy bottom. Example Sand catlet [Leptoglanis cf dorae].

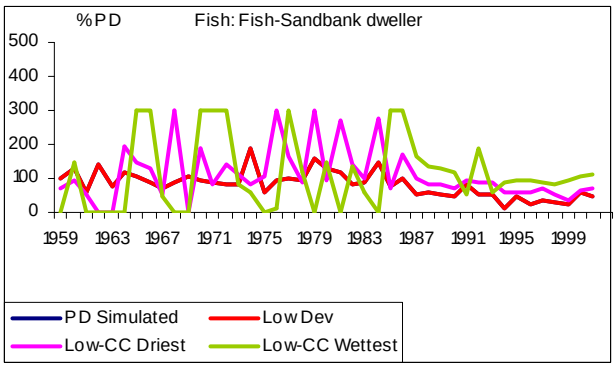
Site 1: Cubango River @ Capico



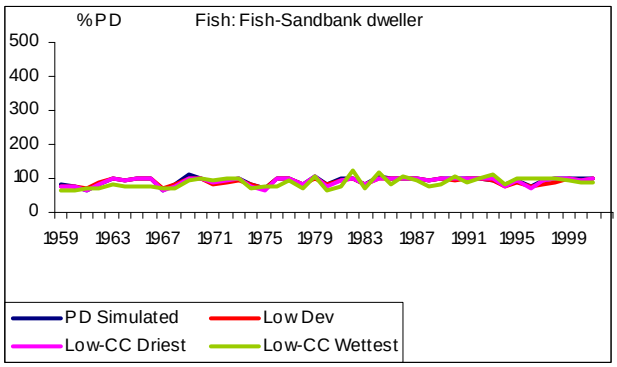
Site 2: Cubango River @ Mucundi



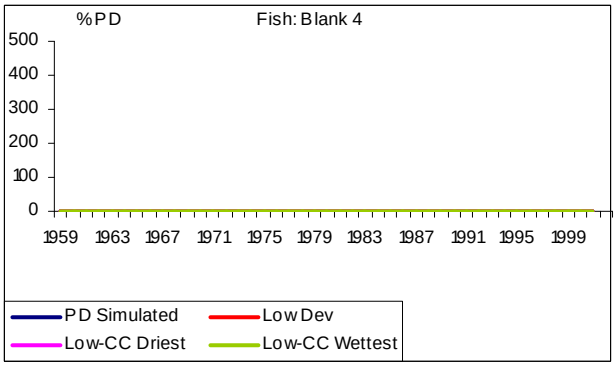
Site 3: Cuito River @ Cuito Cuanavale



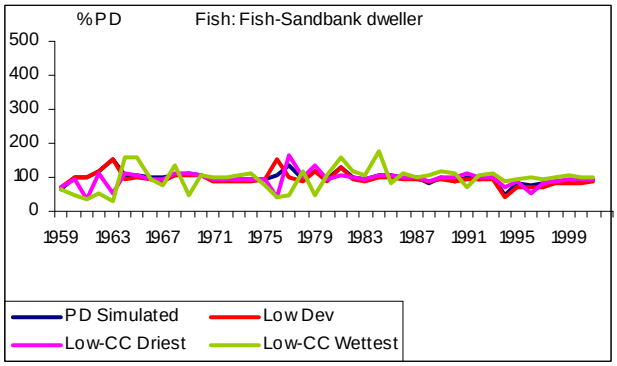
Site 4: Okavango River @ Rundu



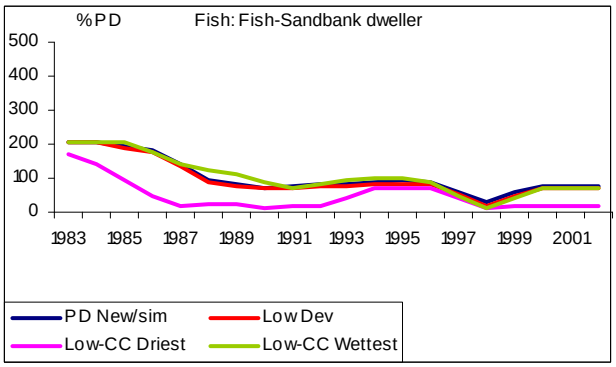
Site 5: Okavango River @ Popa Falls



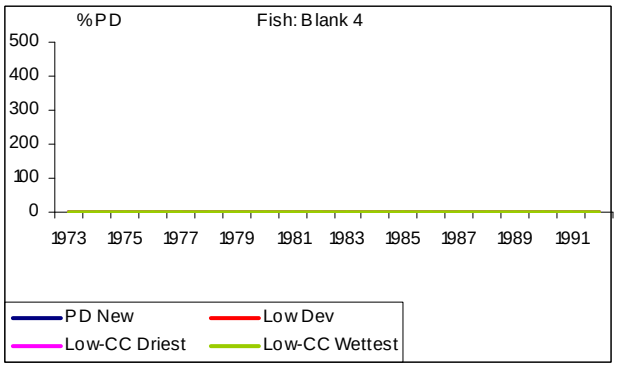
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

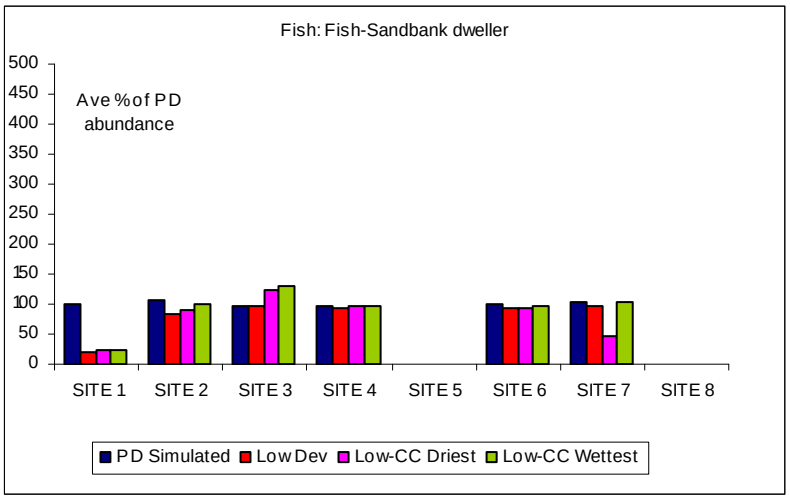


Site 8: Boteti River



Summary change per scenario

Depend on active sandbanks with flowing water and seasonal natural variation of water levels.



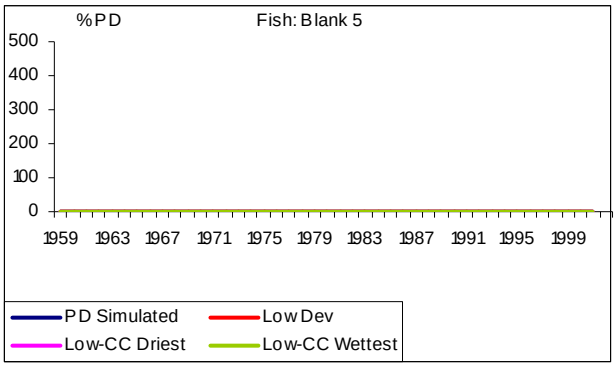
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

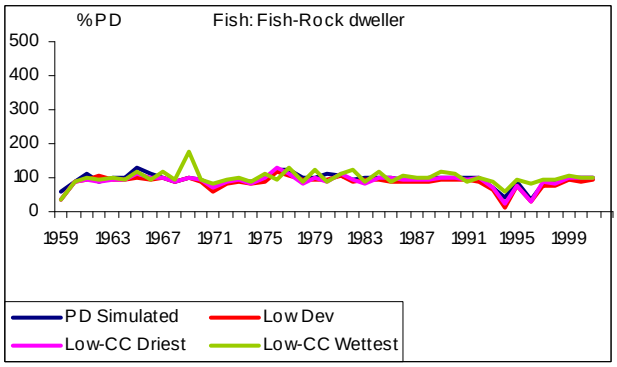
3.5.5 Fish-Rock dweller

(rheophillic species of riffles and rapids)- Fish species living amongst rocks and in crevices in flowing water. Example Southern stargazer [Amphilius uranoscopus].

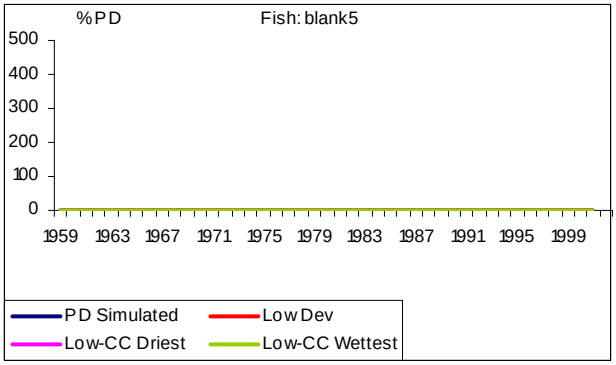
Site 1: Cubango River @ Capico



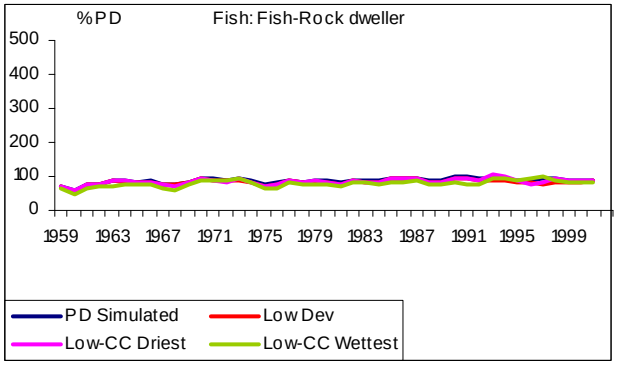
Site 2: Cubango River @ Mucundi



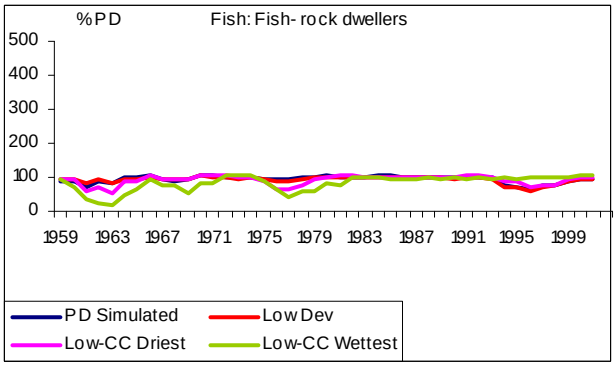
Site 3: Cuito River @ Cuito Cuanavale



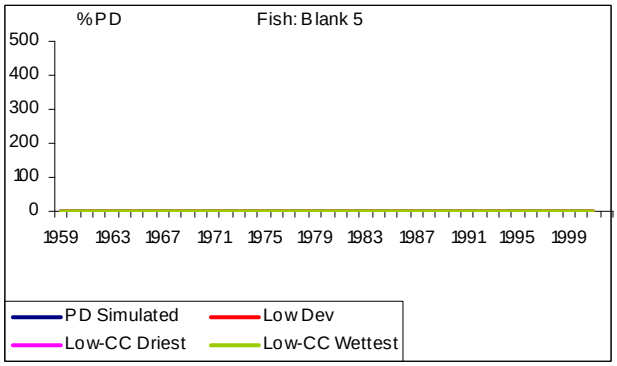
Site 4: Okavango River @ Rundu



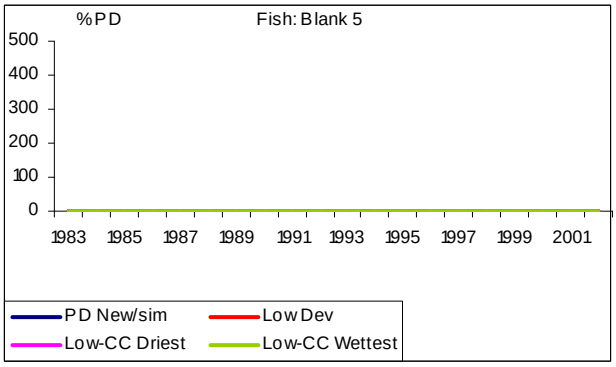
Site 5: Okavango River @ Popa Falls



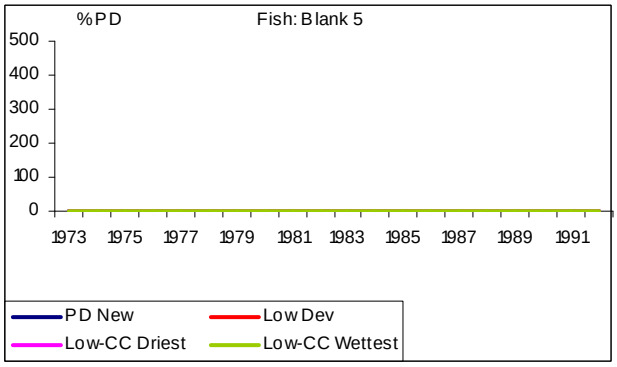
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

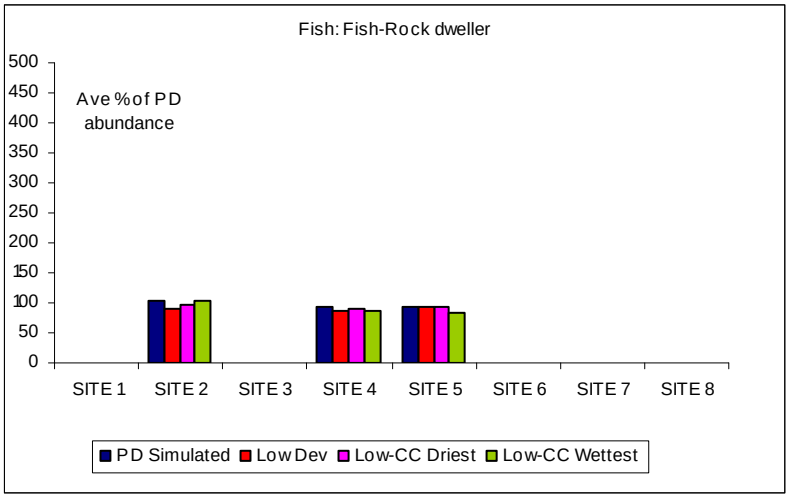


Site 8: Boteti River



Summary change per scenario

Depend on presence of a rocky bottom and flowing water as well as natural variation in water level.



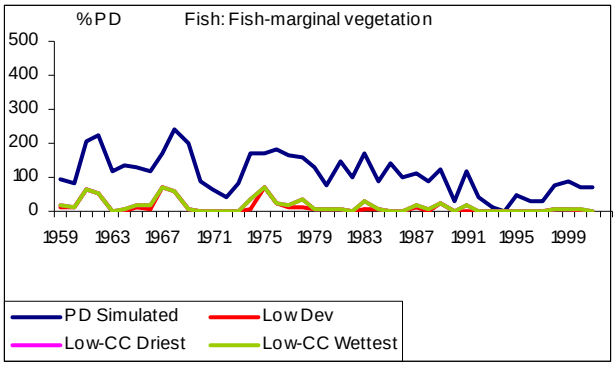
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

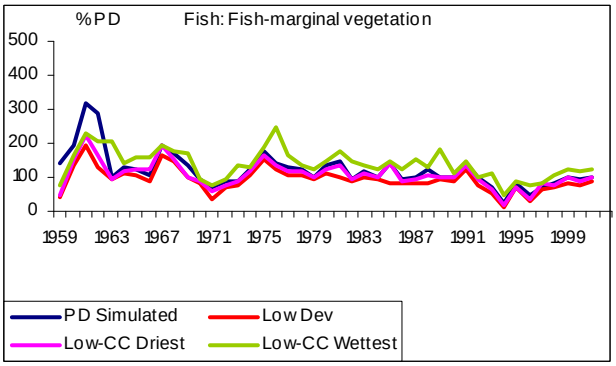
3.5.6 Fish-marginal vegetation

(Species living amongst marginal vegetation on edge of channels.)- Fish species living mainly amongst vegetation on margin of river and may move into floodplains during flood conditions. Example Banded tilapia [Tilapia sparrmanii].

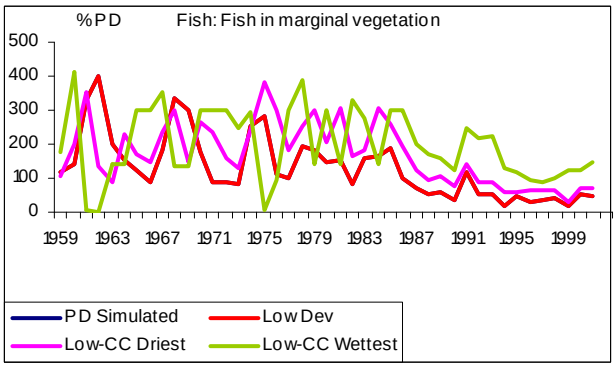
Site 1: Cubango River @ Capico



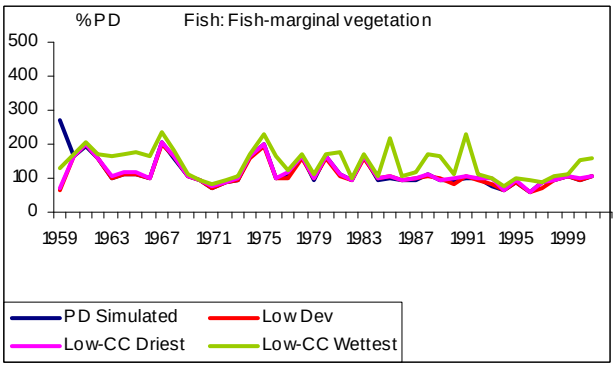
Site 2: Cubango River @ Mucundi



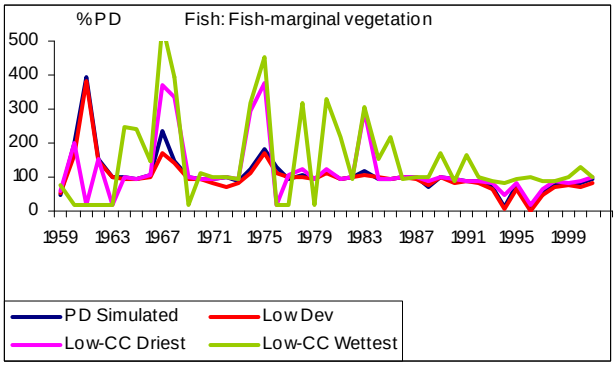
Site 3: Cuito River @ Cuito Cuanavale



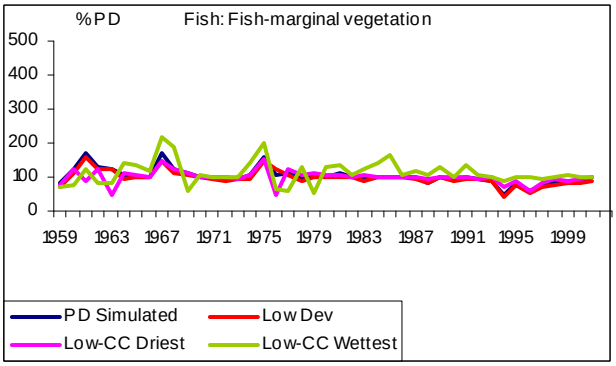
Site 4: Okavango River @ Rundu



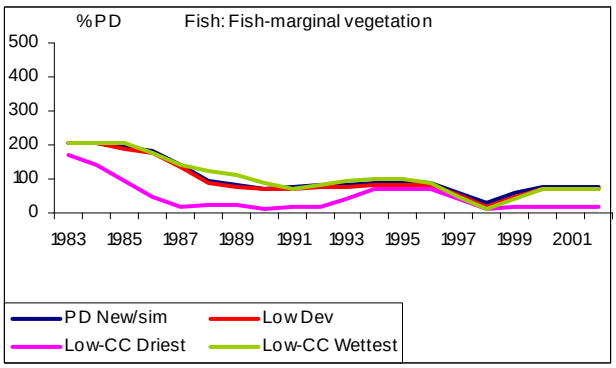
Site 5: Okavango River @ Popa Falls



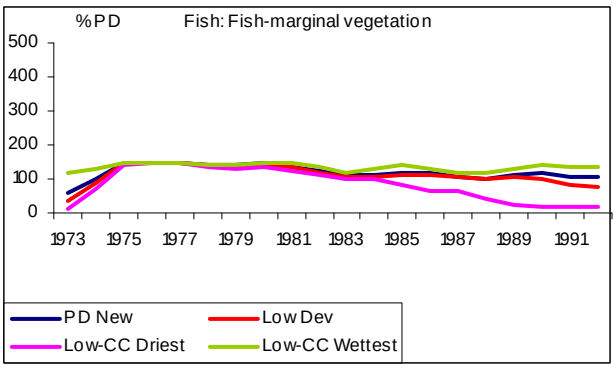
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

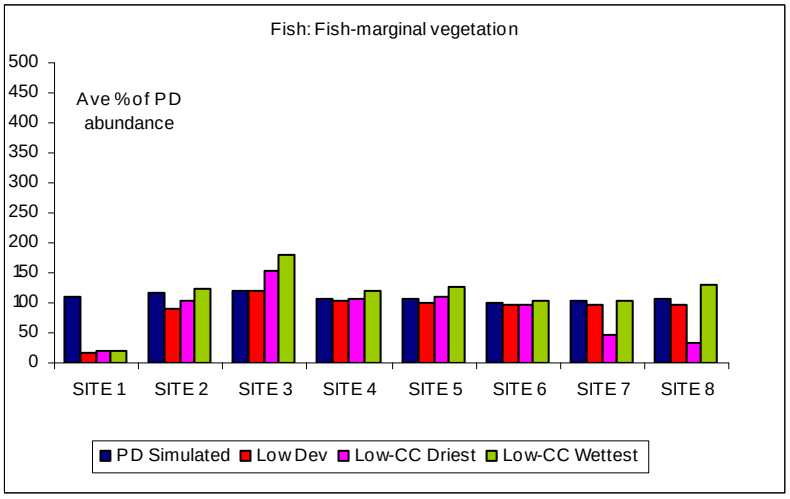


Site 8: Boteti River



Summary change per scenario

Depend on the presence of marginal vegetation, stable soils and naturally varying water levels for establishment of emergent and submerged vegetation.



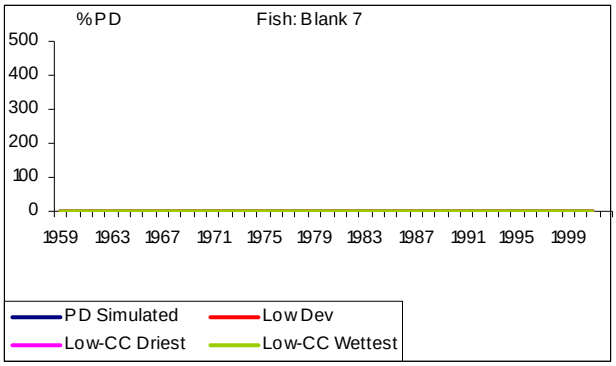
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

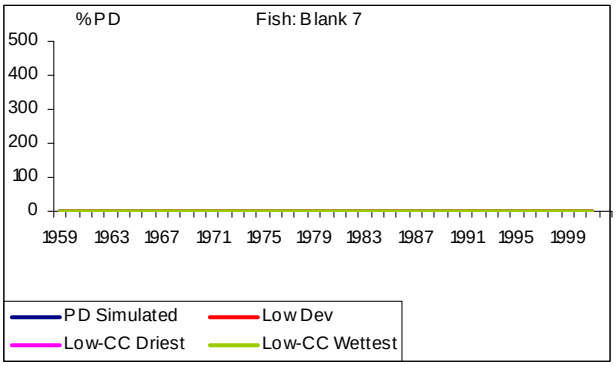
3.5.7 Fish in backwaters

(Fish species living in vegetated pools and backwaters.)- Fish species living mainly amongst vegetation on margin of river and associated backwaters during low water level conditions. May move into floodplains during flood conditions. Example Okavango tilapia [Tilapia ruweti].

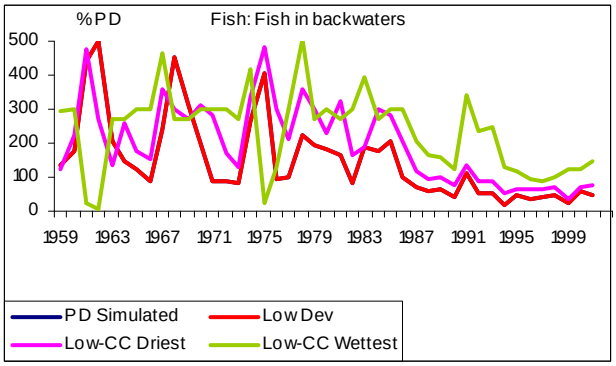
Site 1: Cubango River @ Capico



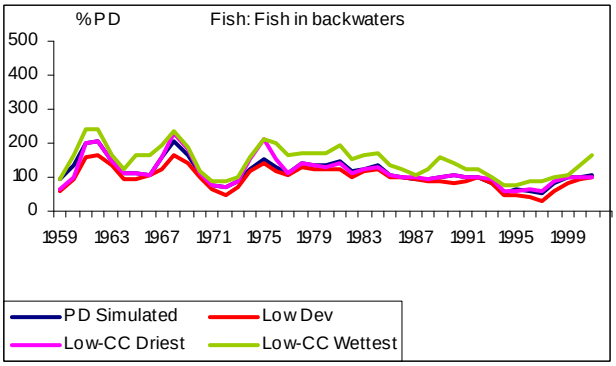
Site 2: Cubango River @ Mucundi



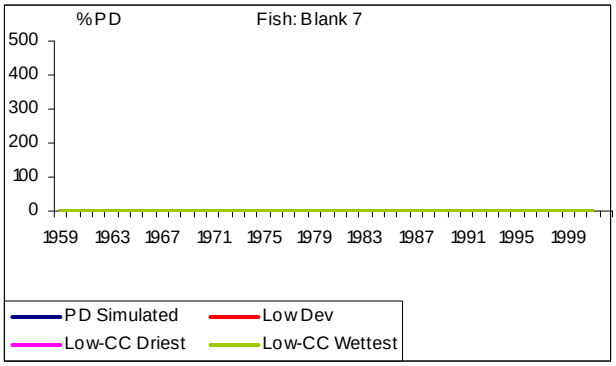
Site 3: Cuito River @ Cuito Cuanavale



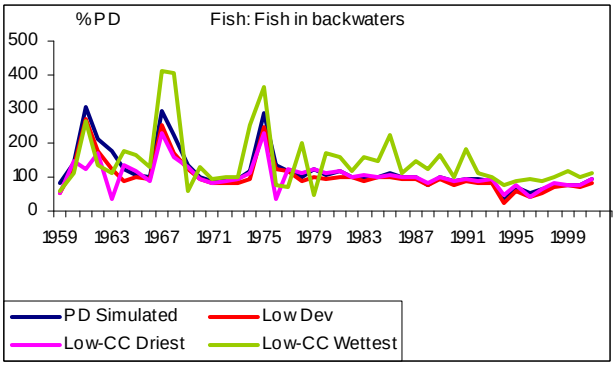
Site 4: Okavango River @ Rundu



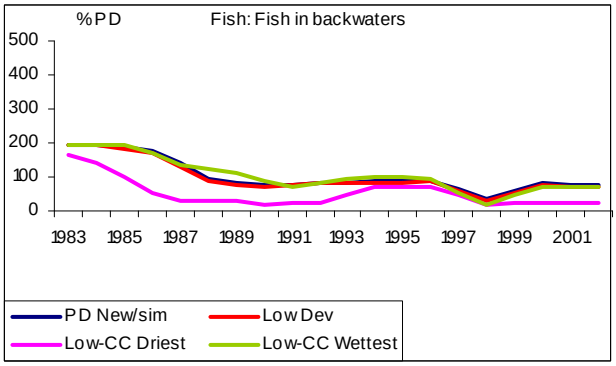
Site 5: Okavango River @ Popa Falls



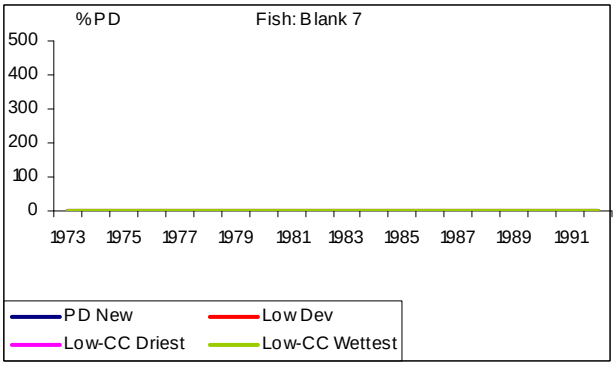
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

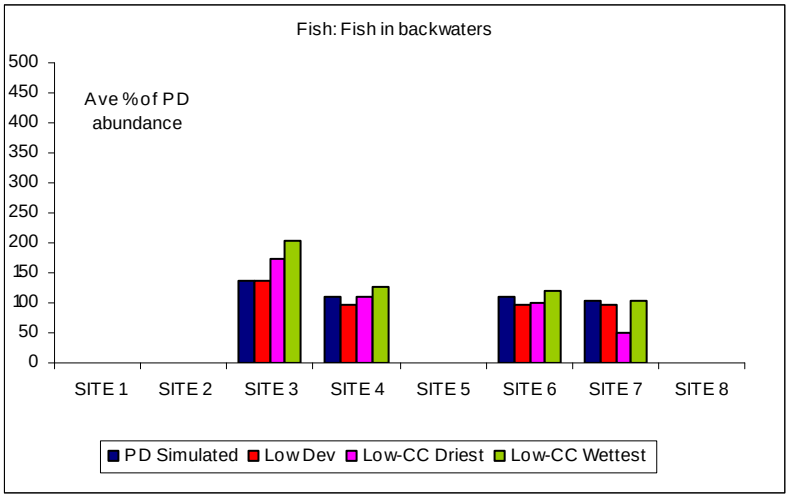


Site 8: Boteti River



Summary change per scenario

Depend on maintenance of oxbows and pools on the margin of the floodplain of the river by normal natural hydrological regime, including standing water conditions during low flow.



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.6. Wildlife

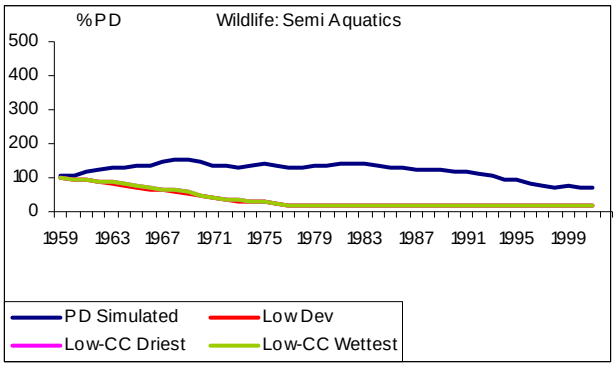
This section provides the time-series for the wildlife indicators under the flow regime resulting from the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Semi Aquatics (hippos, crocodiles)
- Frogs, river snakes
- Lower floodplain grazers
- Middle floodplain grazers
- Outer floodplain grazers.

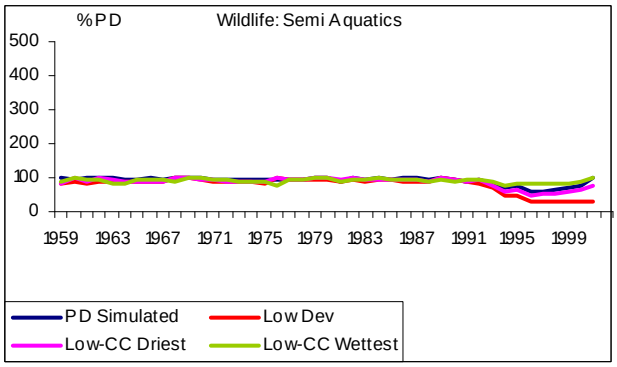
3.6.1 Semi aquatics

(Main channel dwellers, but ranging over banks, floodplains and Islands)- Hippopotamus, crocodile, otters, monitors and terrapins

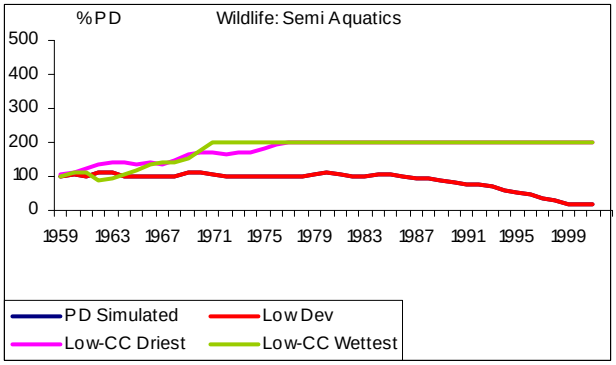
Site 1: Cubango River @ Capico



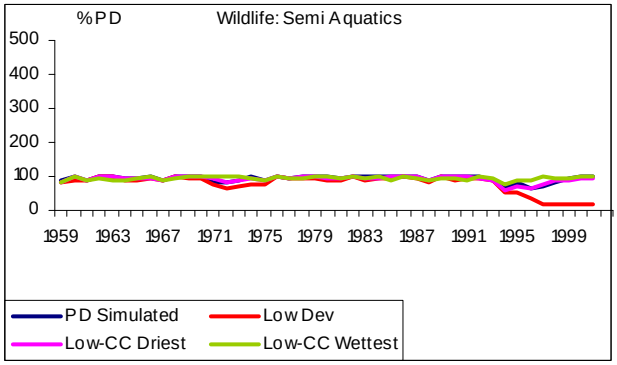
Site 2: Cubango River @ Mucundi



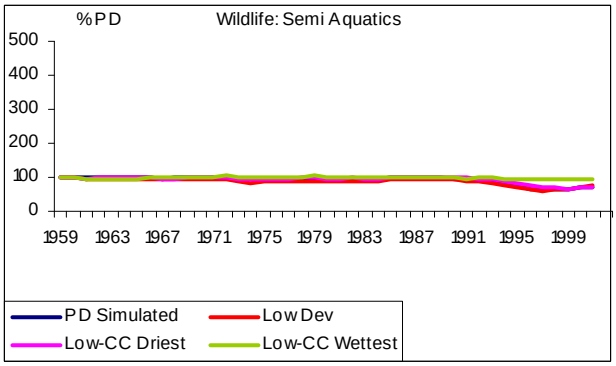
Site 3: Cuito River @ Cuito Cuanavale



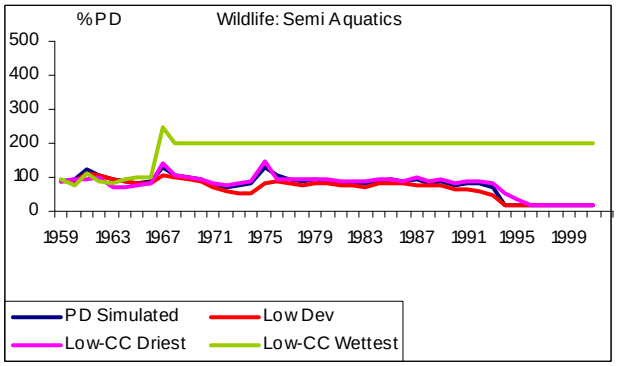
Site 4: Okavango River @ Rundu



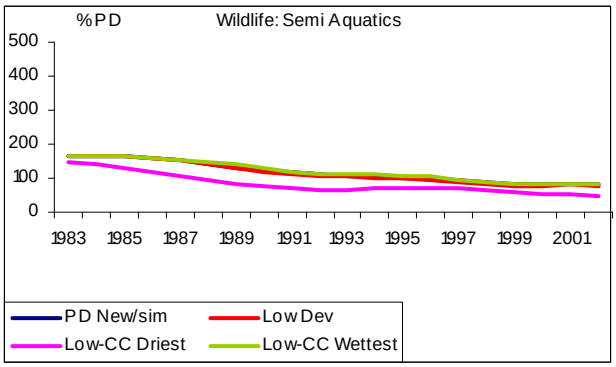
Site 5: Okavango River @ Popa Falls



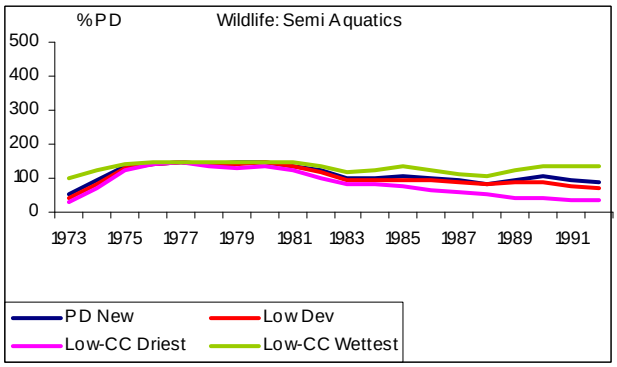
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

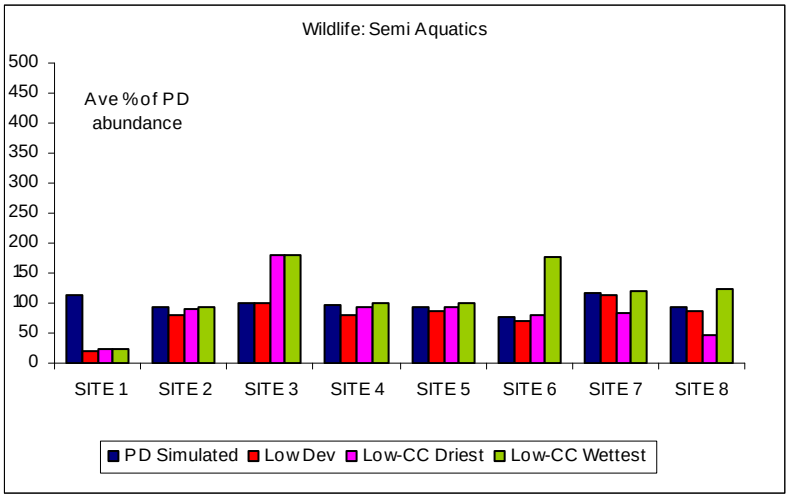


Site 8: Boteti River



Summary change per scenario

Particularly sensitive to dry season water depth for habitat and island integrity.



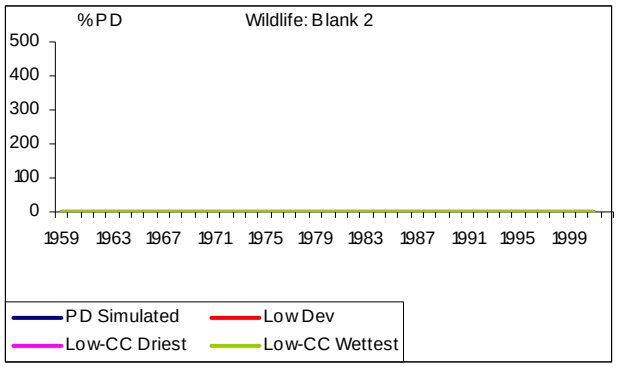
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

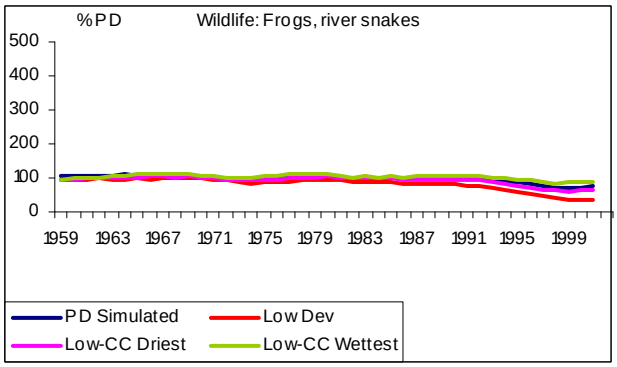
3.6.2 Frogs, river snakes

(Pools, permanent swamp, lower floodplain areas.)- Snakes, ridged frogs, musk shrews

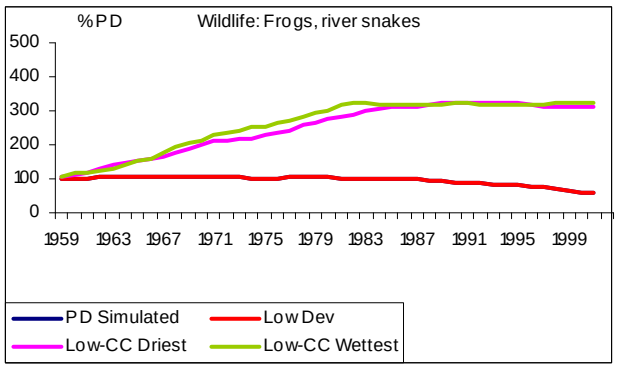
Site 1: Cubango River @ Capico



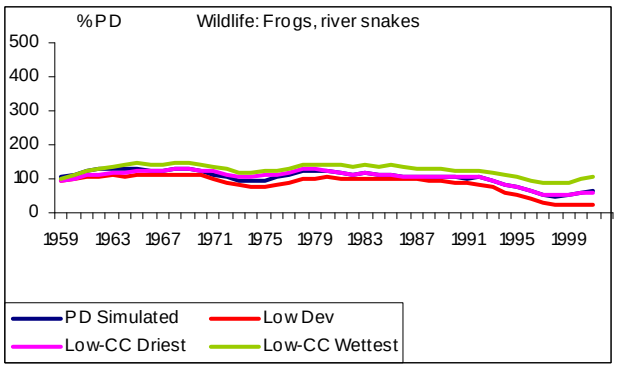
Site 2: Cubango River @ Mucundi



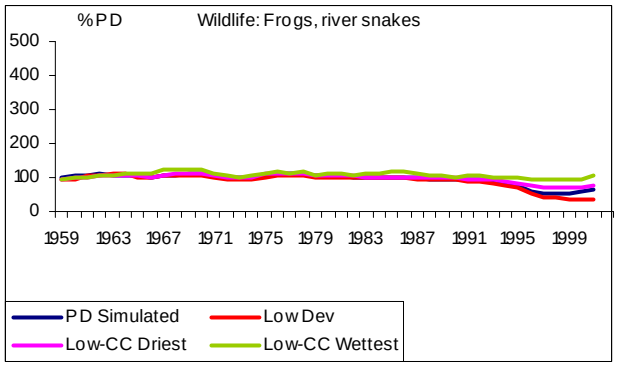
Site 3: Cuito River @ Cuito Cuanavale



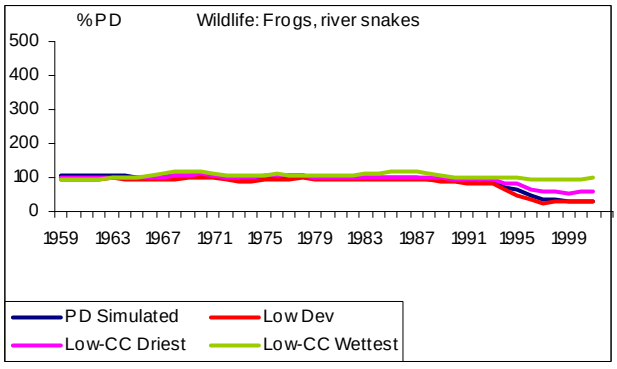
Site 4: Okavango River @ Rundu



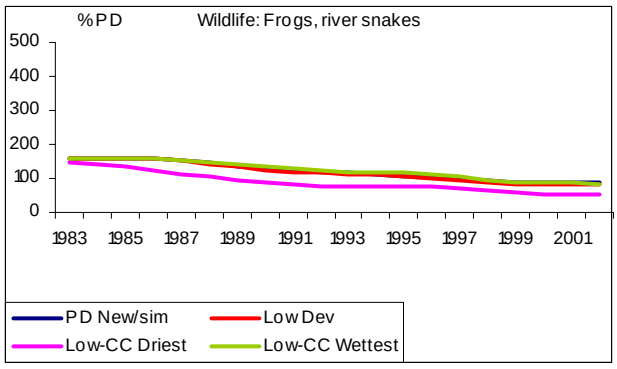
Site 5: Okavango River @ Popa Falls



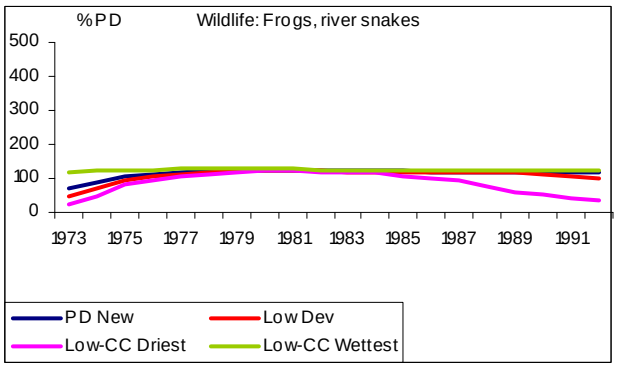
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

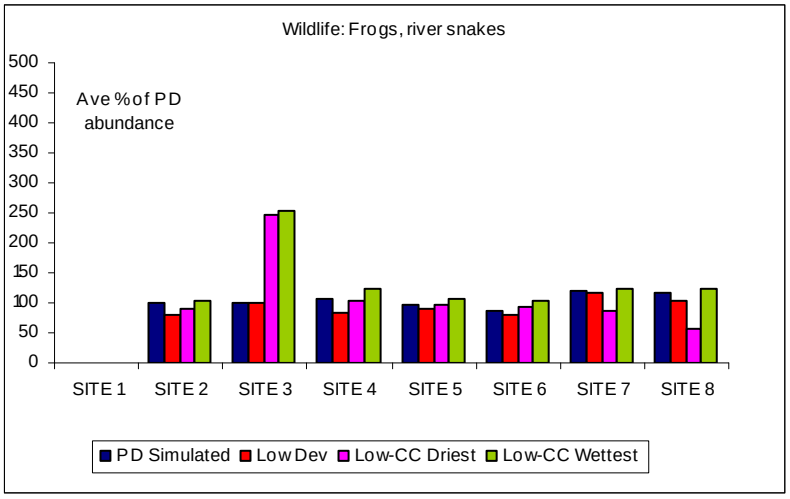


Site 8: Boteti River



Summary change per scenario

Particularly sensitive to dry season water levels and duration to maintain backwaters and marginal vegetation and reduced seasonal floods



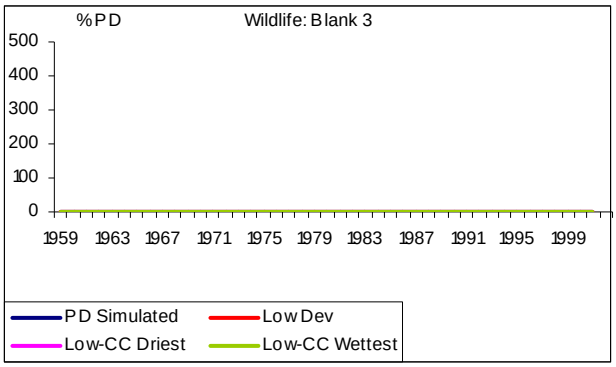
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

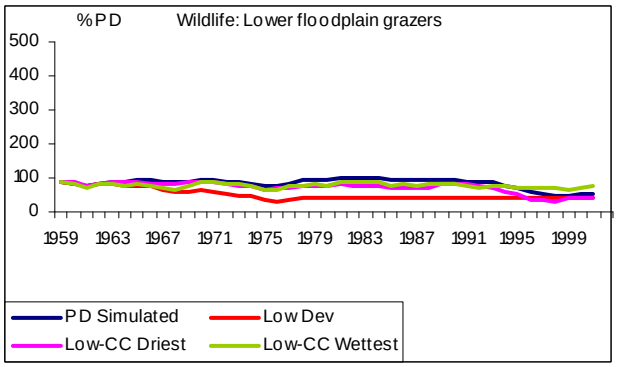
3.6.3 Lower floodplain grazers

(Primary and secondary floodplain)- Elephant, buffalo, tsesebe, warthog

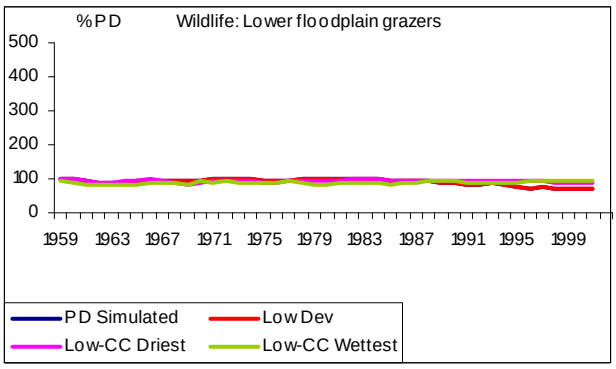
Site 1: Cubango River @ Capico



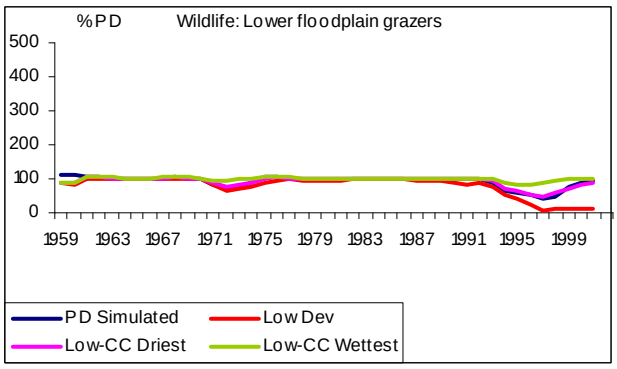
Site 2: Cubango River @ Mucundi



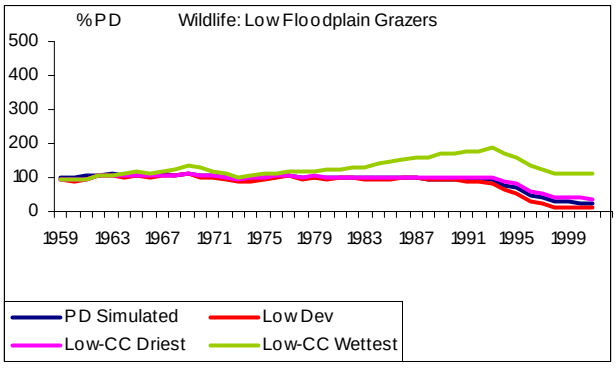
Site 3: Cuito River @ Cuito Cuanavale



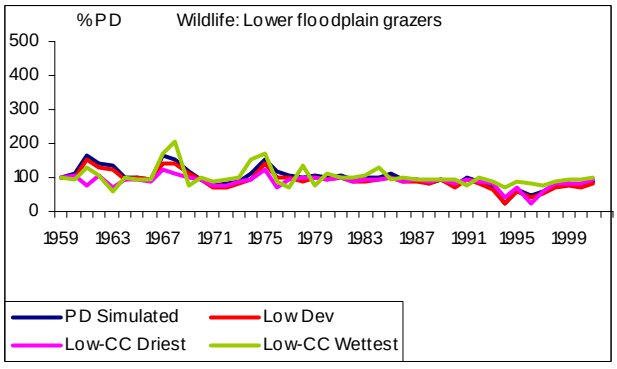
Site 4: Okavango River @ Rundu



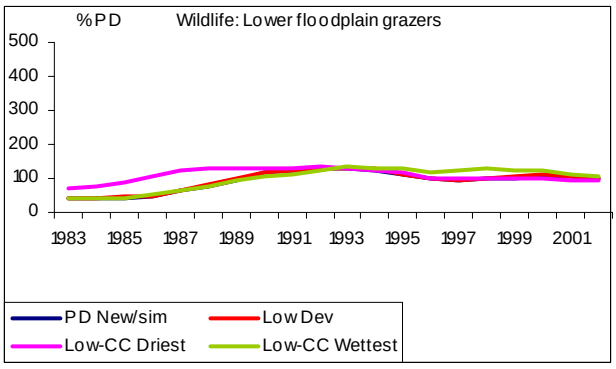
Site 5: Okavango River @ Popa Falls



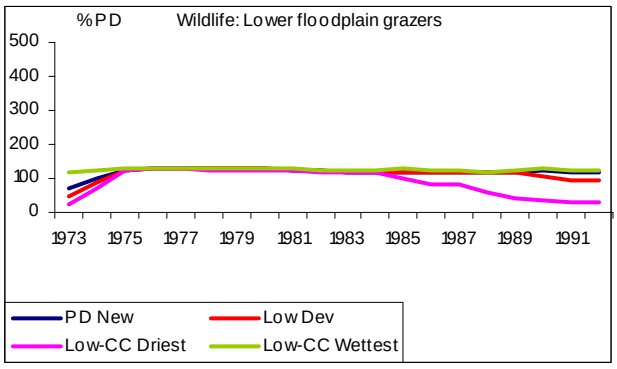
Site 6: Okavango River @ Pan Handle



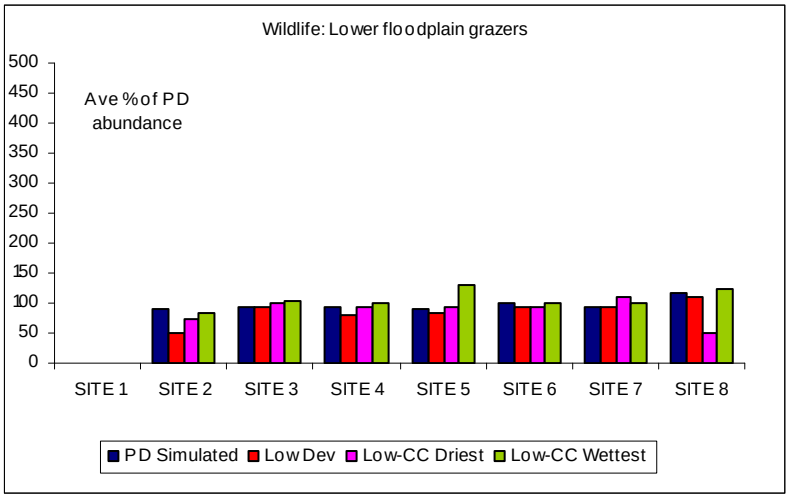
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Need to seasonal floods 2-6 months

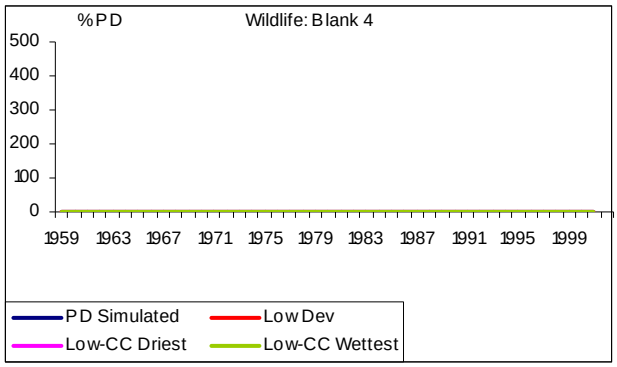


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

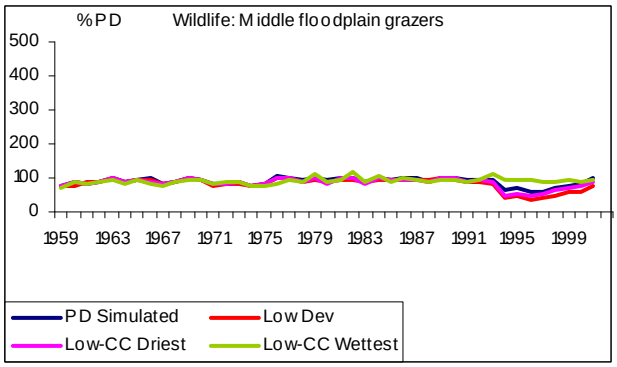
3.6.4 Middle floodplain grazers

(Secondary and tertiary floodplain)- Wildebeest, zebra, impala, duiker, aarvark, mice

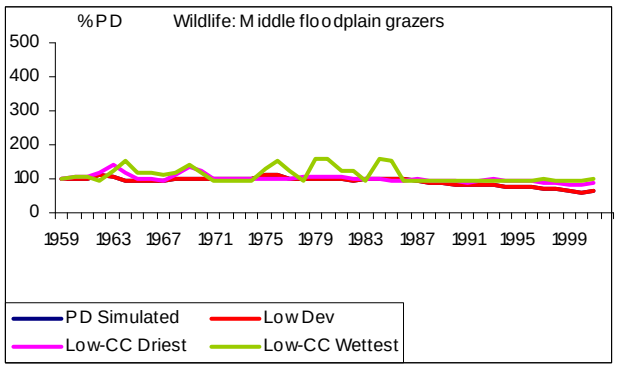
Site 1: Cubango River @ Capico



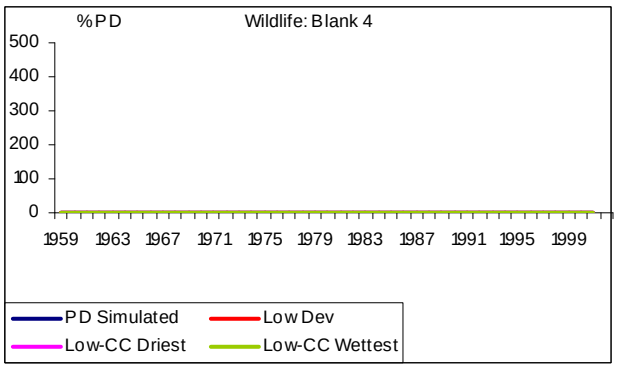
Site 2: Cubango River @ Mucundi



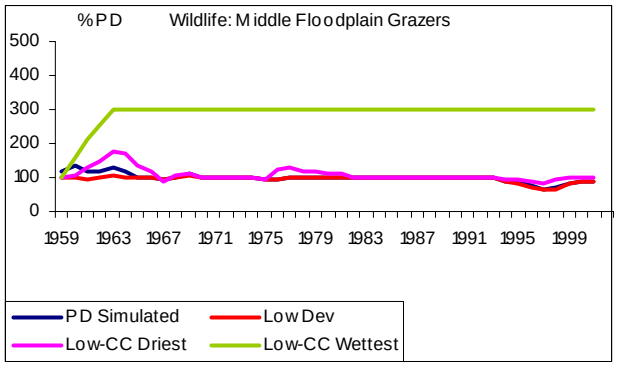
Site 3: Cuito River @ Cuito Cuanavale



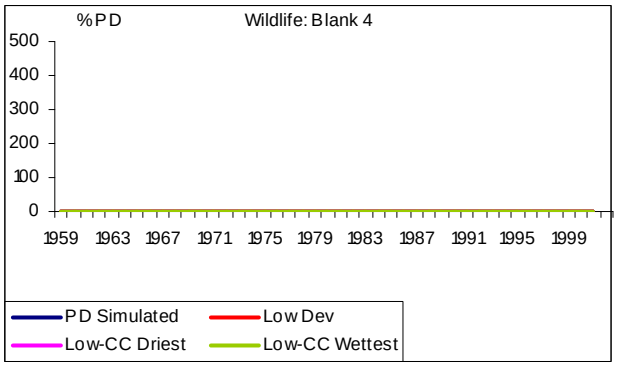
Site 4: Okavango River @ Rundu



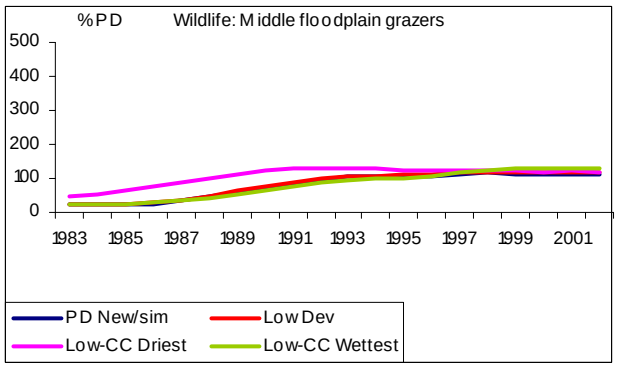
Site 5: Okavango River @ Popa Falls



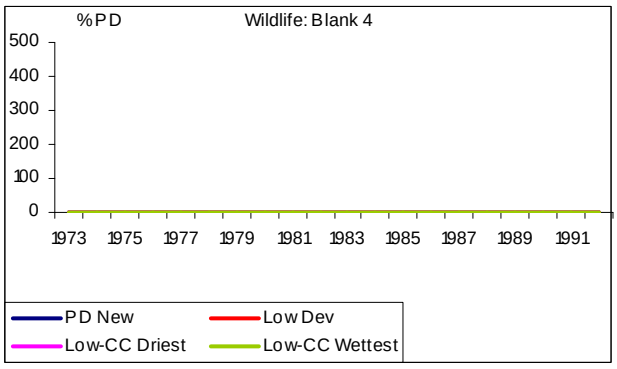
Site 6: Okavango River @ Pan Handle



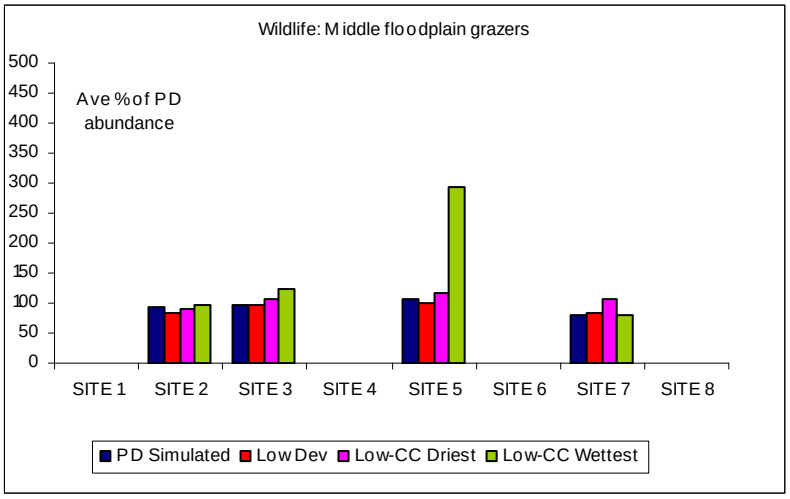
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Need periodic flooding

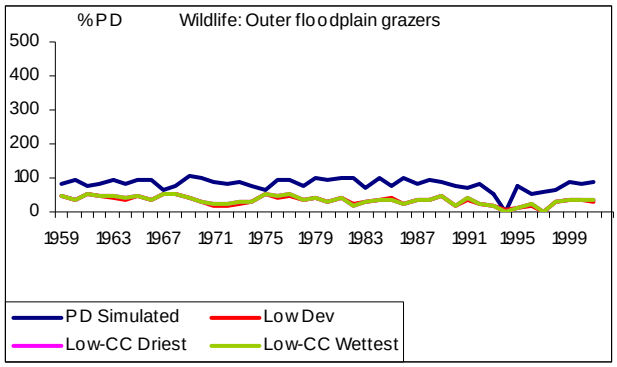


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

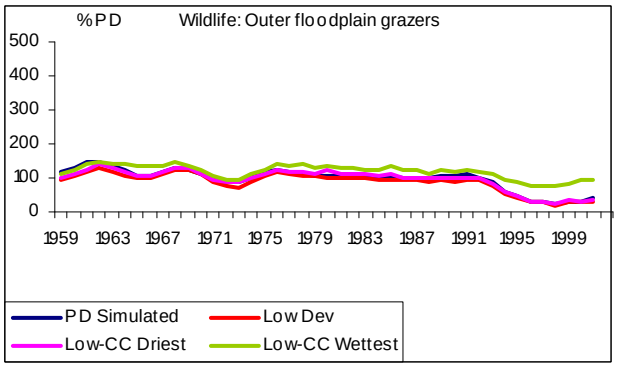
3.6.5 Outer floodplain grazers

(Permanent swamp, primary and secondary floodplain)- Lechwe, sitatunga, reedbuck, waterbuck,

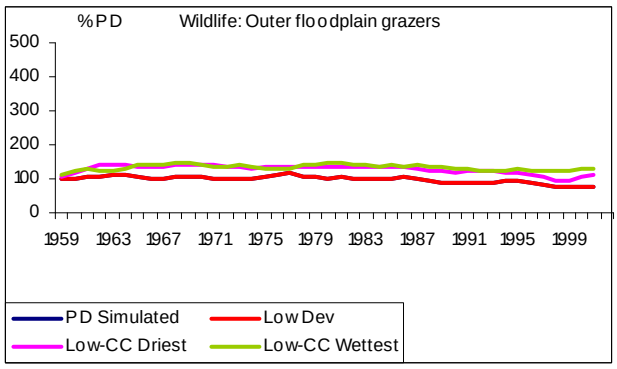
Site 1: Cubango River @ Capico



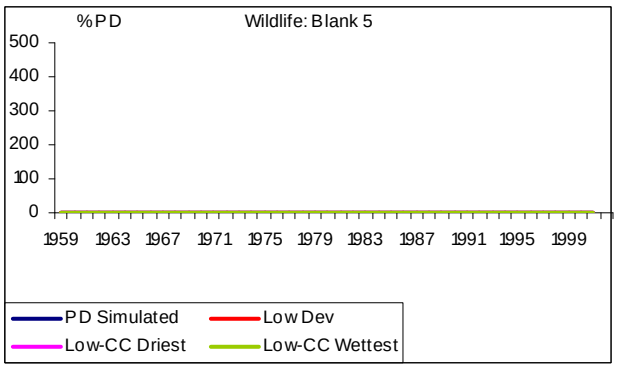
Site 2: Cubango River @ Mucundi



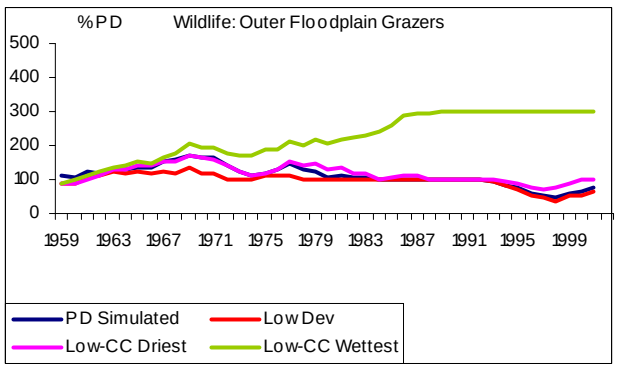
Site 3: Cuito River @ Cuito Cuanavale



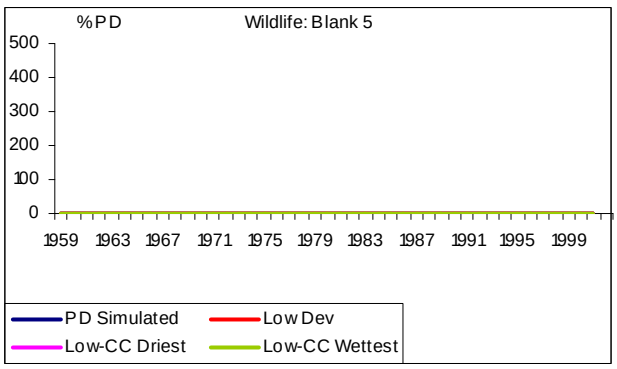
Site 4: Okavango River @ Rundu



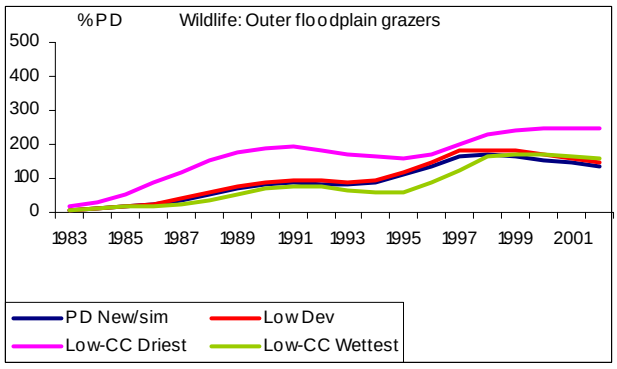
Site 5: Okavango River @ Popa Falls



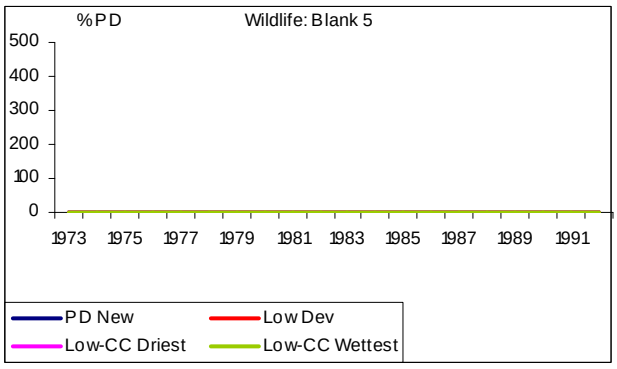
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

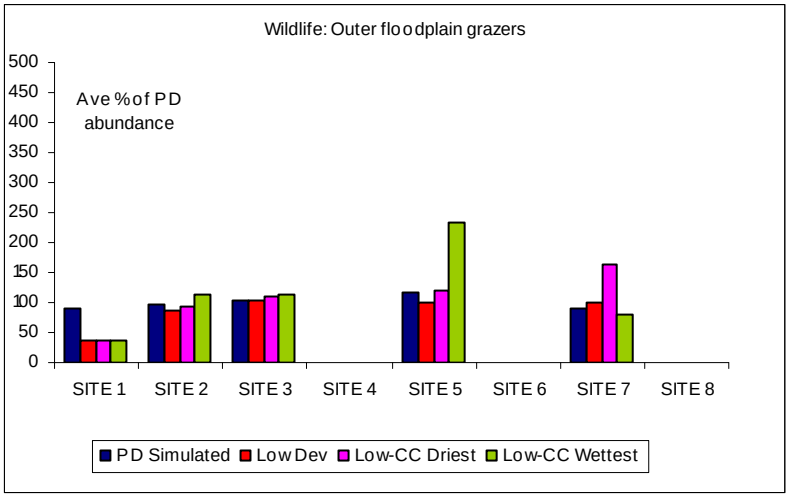


Site 8: Boteti River



Summary change per scenario

need seasonal floods 4-6 months



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.7. Birds

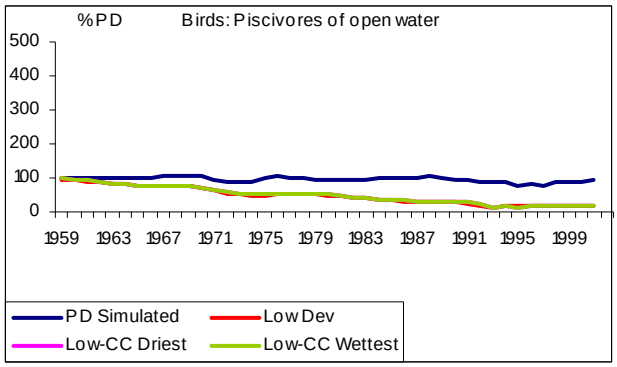
This section provides the time-series for bird indicators under the flow regime resulting from the low scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Piscivores - open water
- Piscivores - shallow water
- Piscivores and invertebrate feeders
- Specialists - floodplains
- Specialists - water lilies
- Specialists - fruit trees
- Breeders - reedbeds, floodplains
- Breeders - overhanging trees
- Breeders - banks
- Breeders - rocks, sandbars.

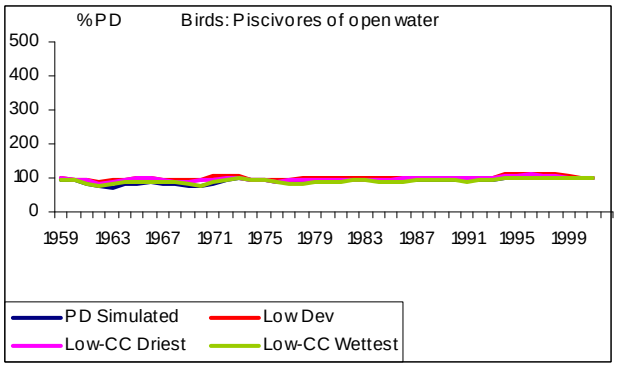
3.7.1 Piscivores, open water

(Predominantly feeds on fish, main river/adjoining pools)- Kingfishers, cormorants, darter

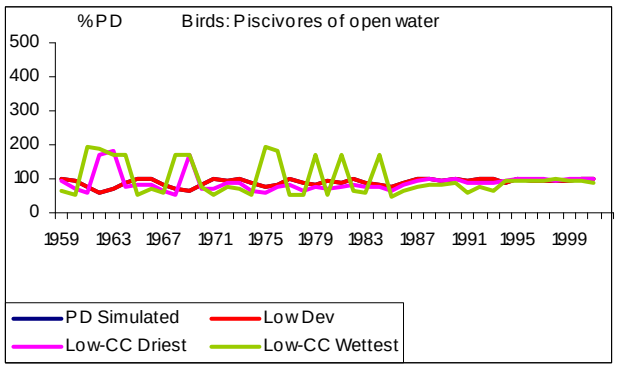
Site 1: Cubango River @ Capico



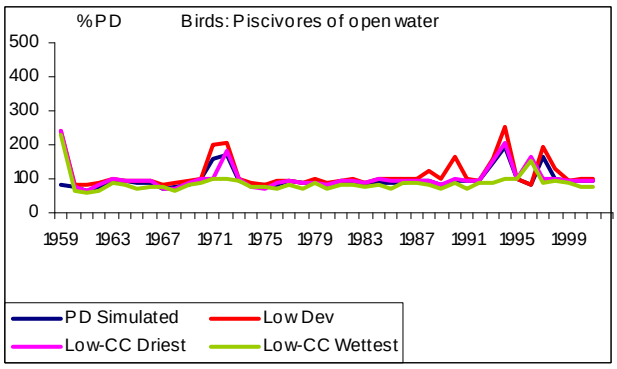
Site 2: Cubango River @ Mucundi



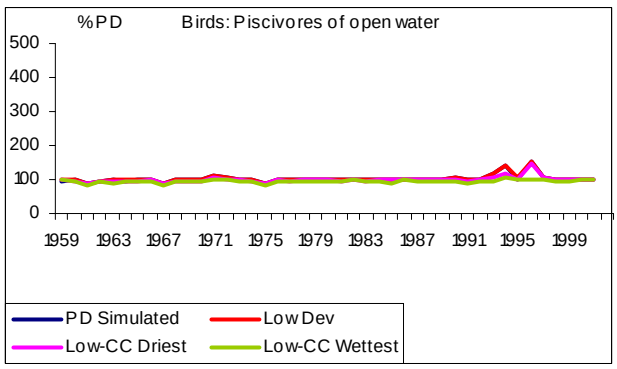
Site 3: Cuito River @ Cuito Cuanavale



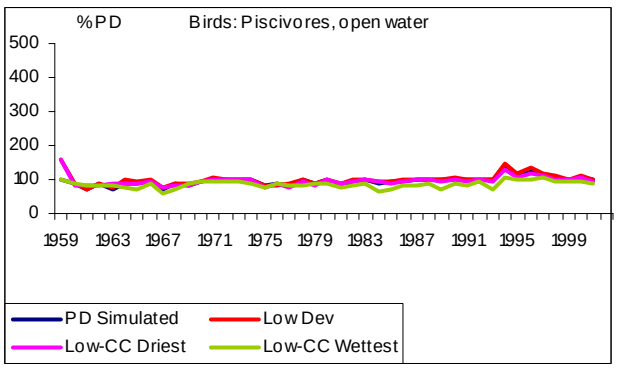
Site 4: Okavango River @ Rundu



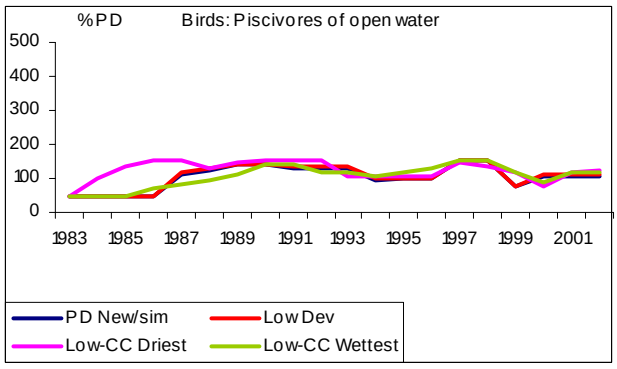
Site 5: Okavango River @ Popa Falls



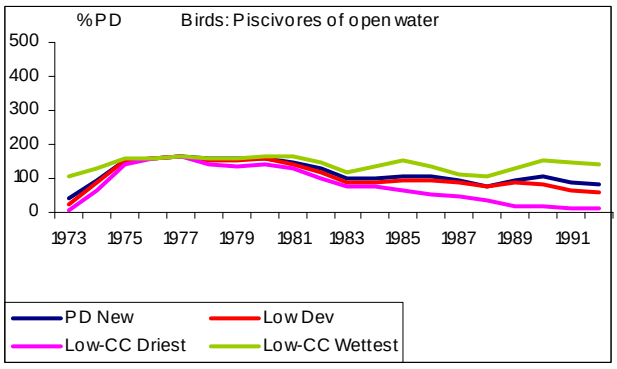
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

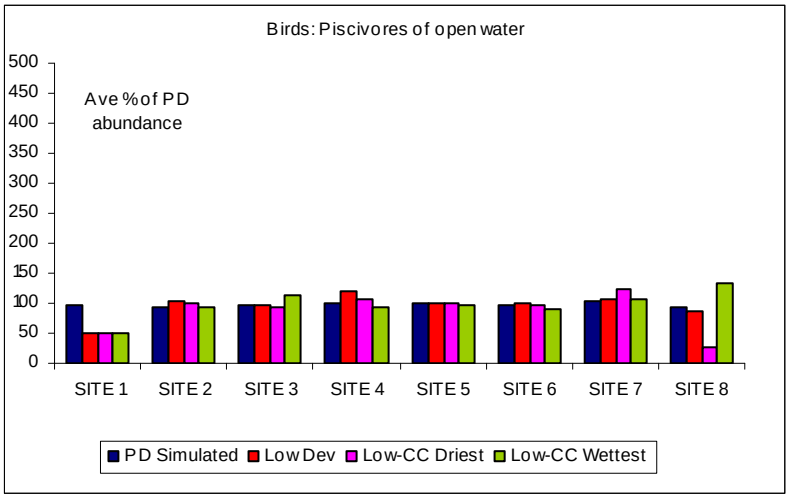


Site 8: Boteti River



Summary change per scenario

These birds generally thrive during low flow levels because their fish prey is more concentrated and vulnerable in the main river and/or isolated pools. However, at prolonged low flows or excessively low flows the prey base will be negatively affected if the floodplains where fish breed are not inundated.



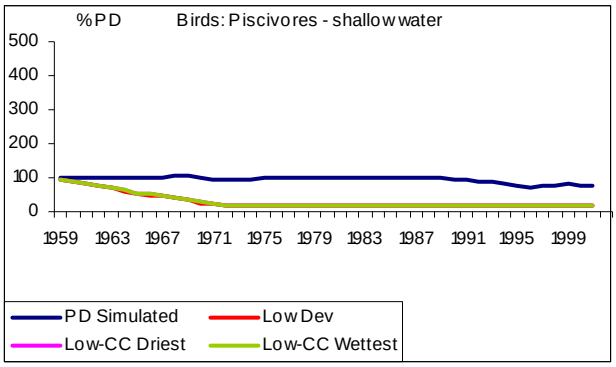
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

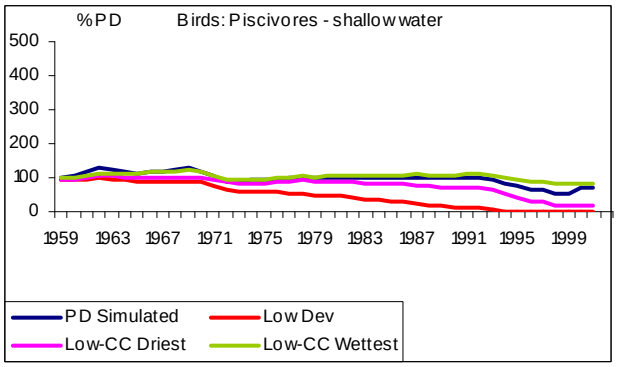
3.7.2 Piscivores, shallow water

(Hunts from overhanging trees on shallow backwaters by ambush techniques)- Larger herons/egrets

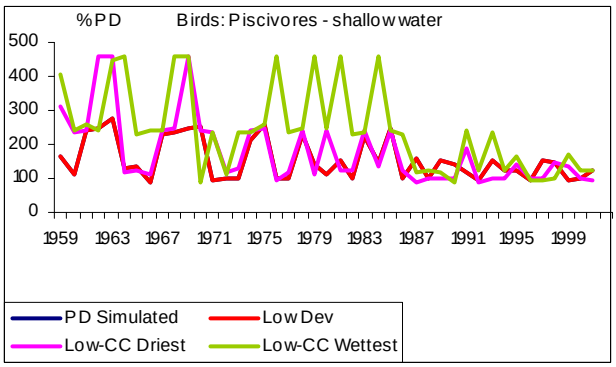
Site 1: Cubango River @ Capico



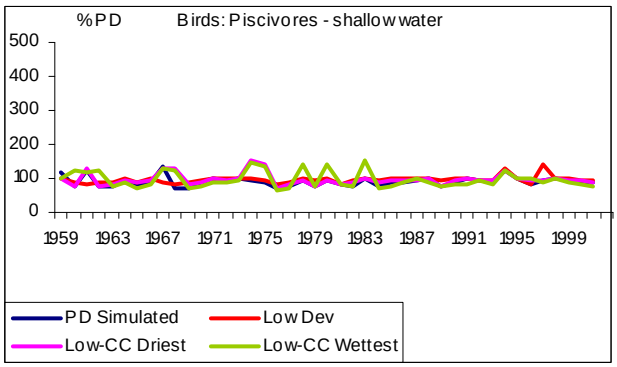
Site 2: Cubango River @ Mucundi



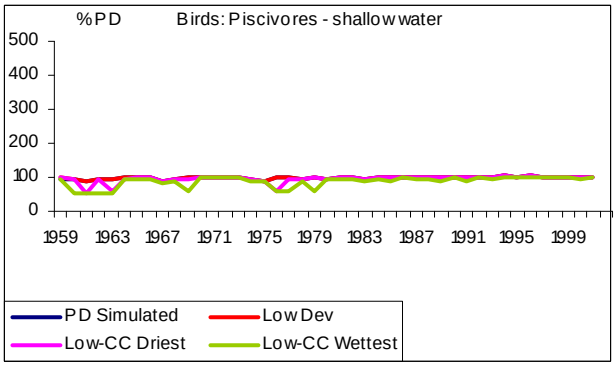
Site 3: Cuito River @ Cuito Cuanavale



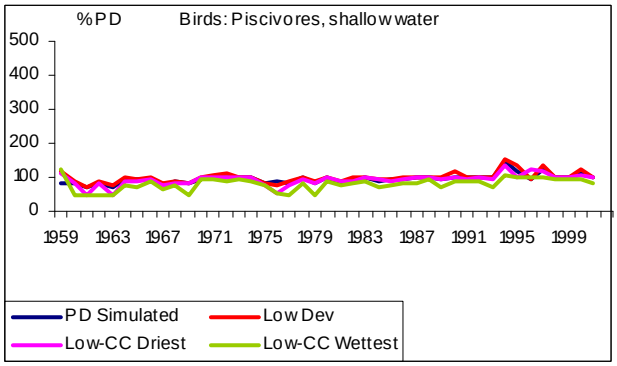
Site 4: Okavango River @ Rundu



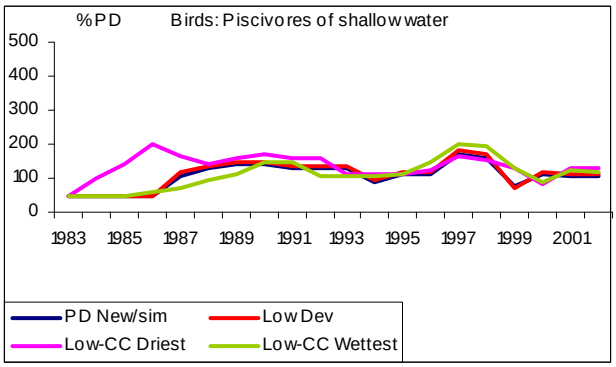
Site 5: Okavango River @ Popa Falls



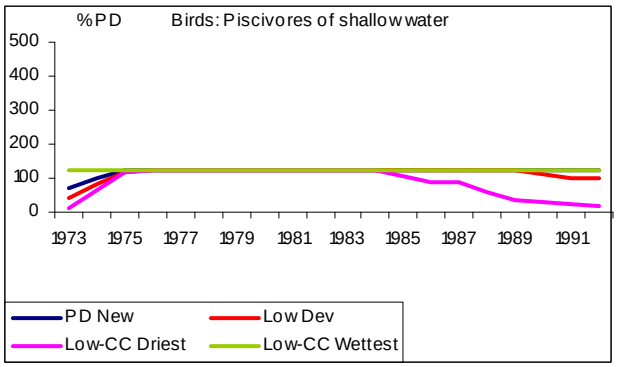
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

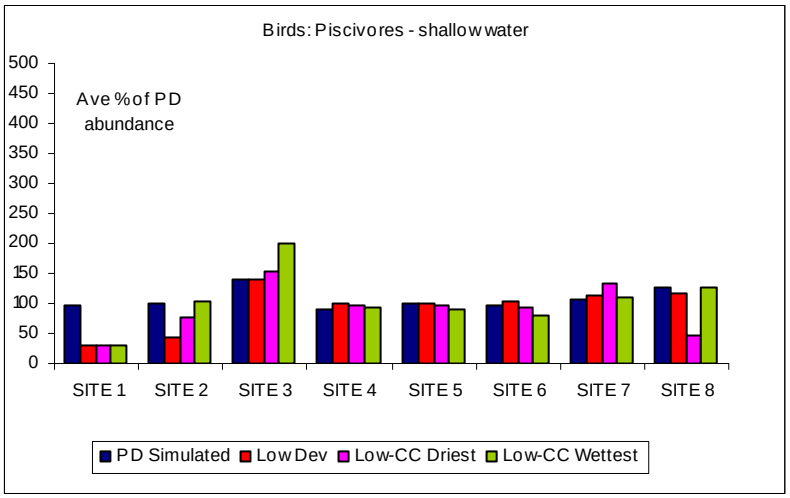


Site 8: Boteti River



Summary change per scenario

The shallower the water in the main channels and on the floodplains, the better for most of these species because prey would be confined into smaller concentrations and hunting opportunities would be improved.



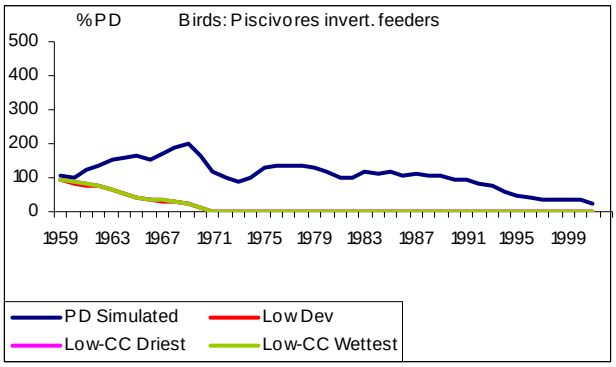
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

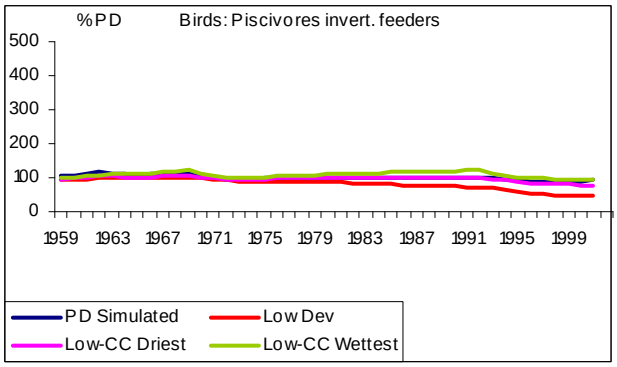
3.7.3 Piscivores invertebrate feeders

(Feed on fish-fry at receding water level times after spawning in flood-plains, or fish trapped in drying pools.) - Little Egret, Black Heron, Glossy Ibis, Saddle-billed Stork, Lapwings

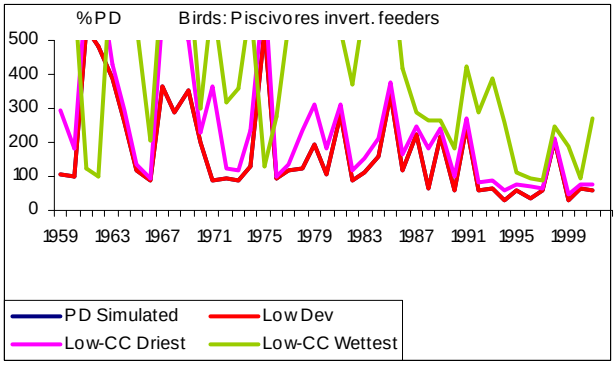
Site 1: Cubango River @ Capico



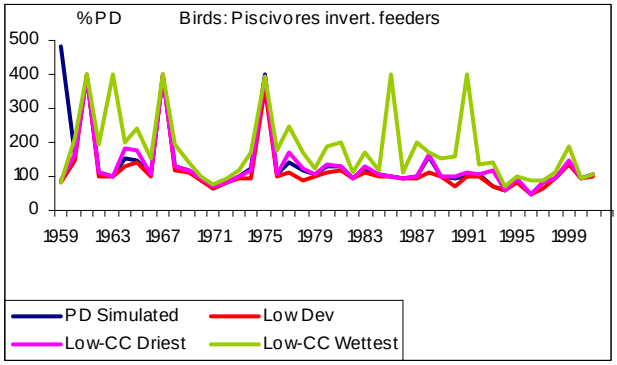
Site 2: Cubango River @ Mucundi



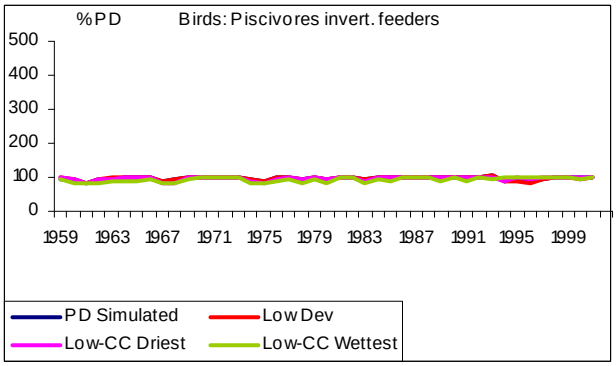
Site 3: Cuito River @ Cuito Cuanavale



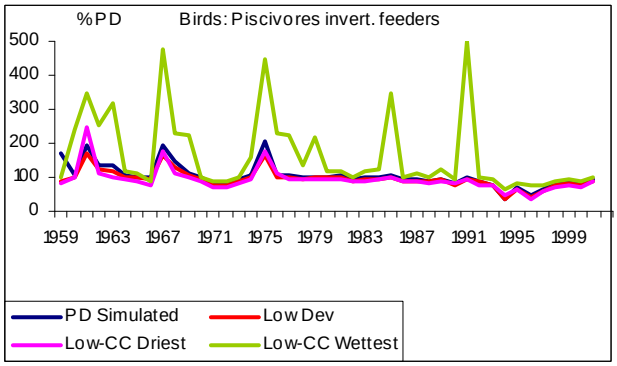
Site 4: Okavango River @ Rundu



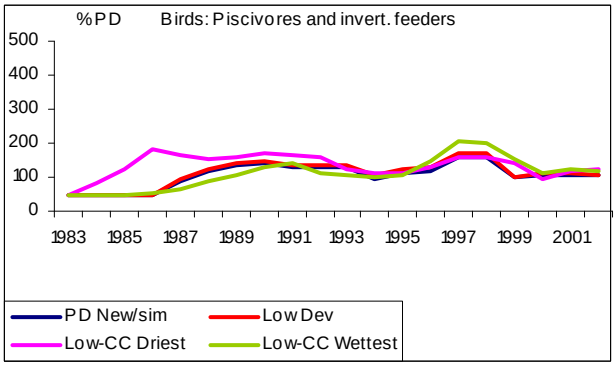
Site 5: Okavango River @ Popa Falls



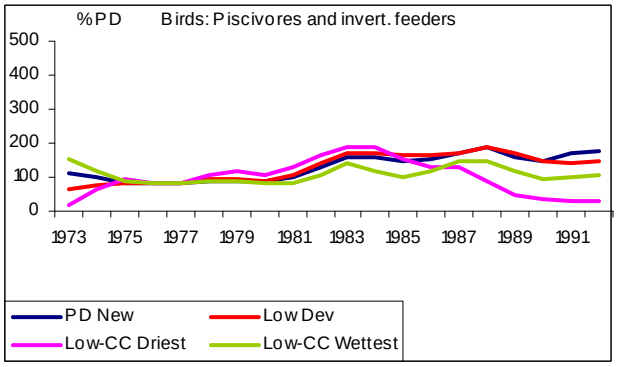
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

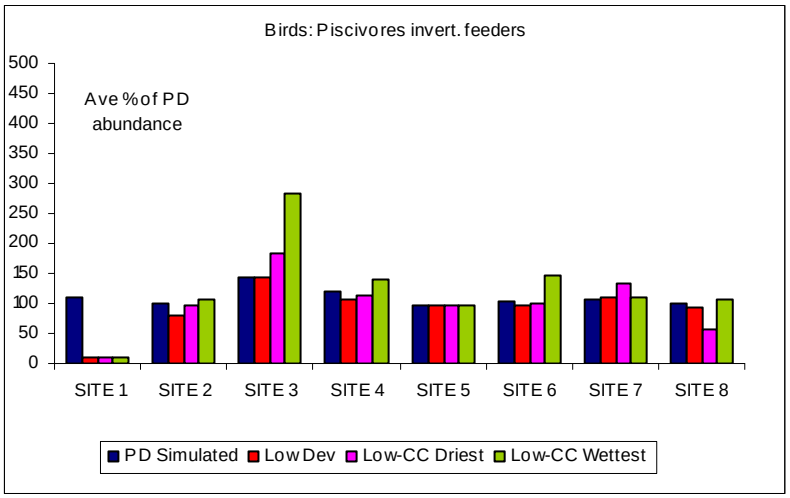


Site 8: Boteti River



Summary change per scenario

Timing and volume of flow are critical for these birds - when the river first overflows its banks onto the floodplains it causes optimal hunting and feeding conditions, and then again when receding waters cause isolated pools, trapping small fish and invertebrates.



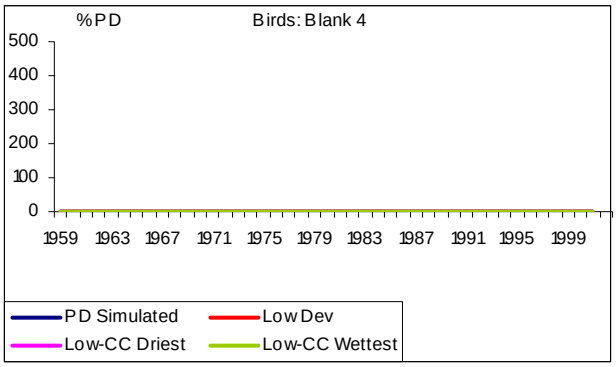
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

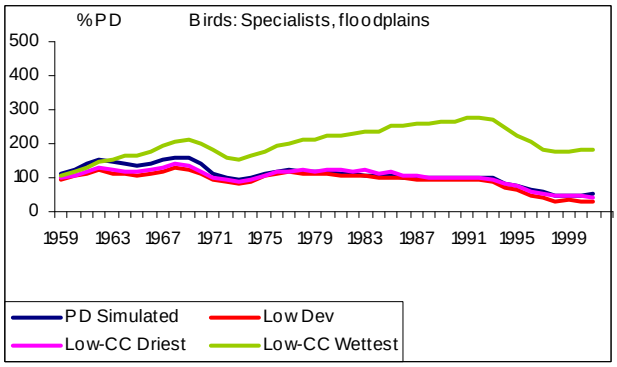
3.7.4 Specialists, floodplains

(Feed on molluscs, frogs, fish or selective vegetation and organisms occurring in shallow floodplain situations)- African Openbill, ducks, geese, Wattled Crane

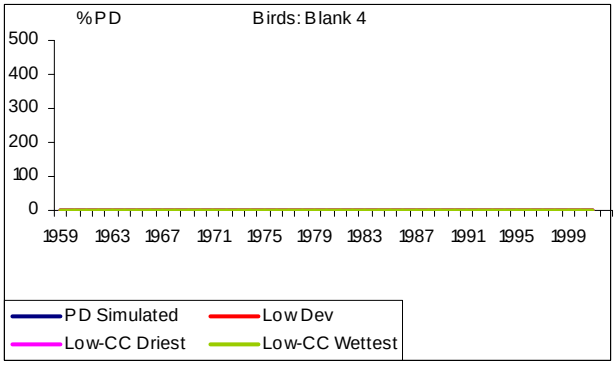
Site 1: Cubango River @ Capico



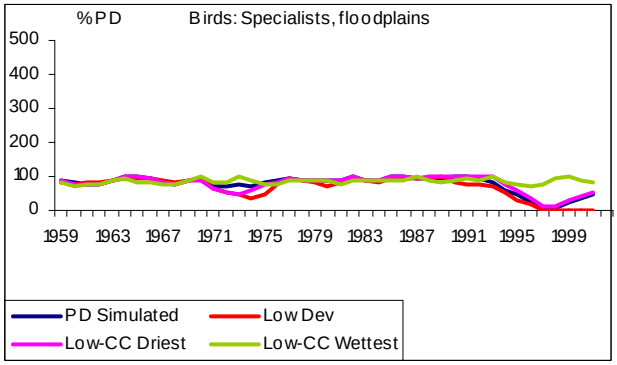
Site 2: Cubango River @ Mucundi



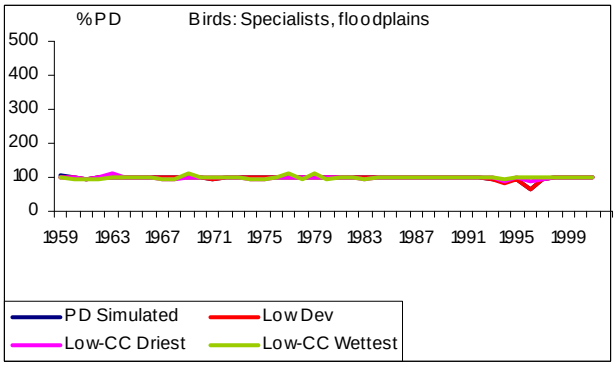
Site 3: Cuito River @ Cuito Cuanavale



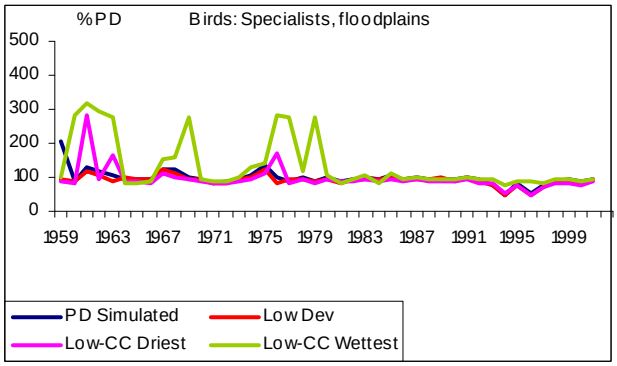
Site 4: Okavango River @ Rundu



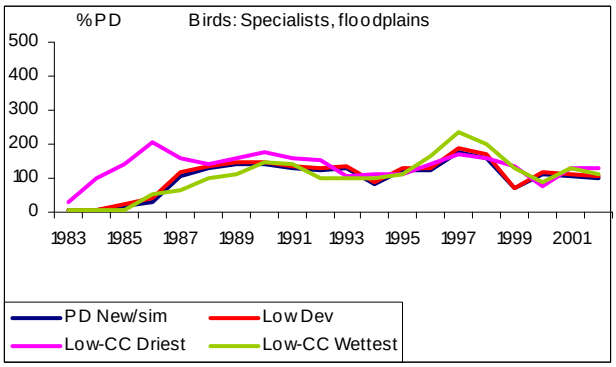
Site 5: Okavango River @ Popa Falls



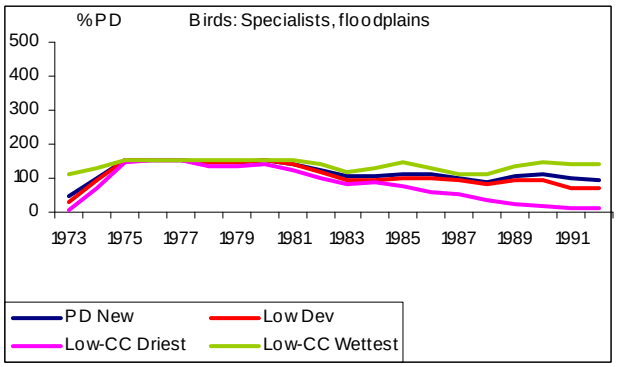
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

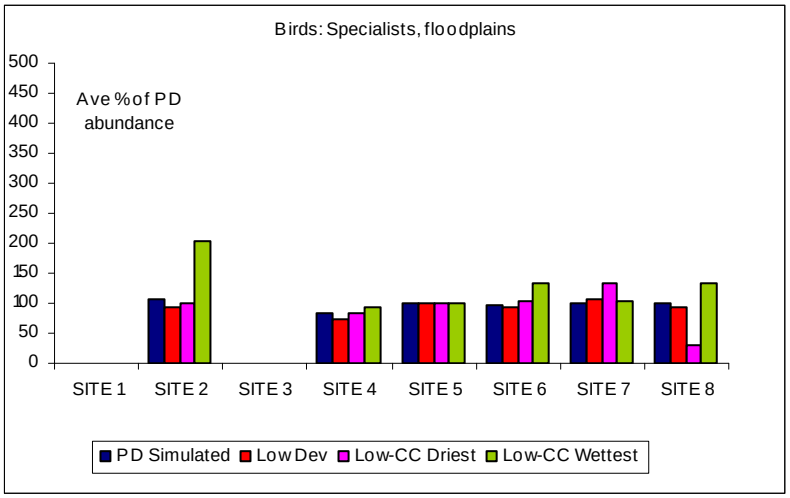


Site 8: Boteti River



Summary change per scenario

These birds utilise floodplain areas when they are newly flooded and food availability is at its optimal level due to new breeding and germination activities, and also when waters are receding and food items are confined and concentrated i.e. inundation and receding of waters is vitally important for this group of indicators.



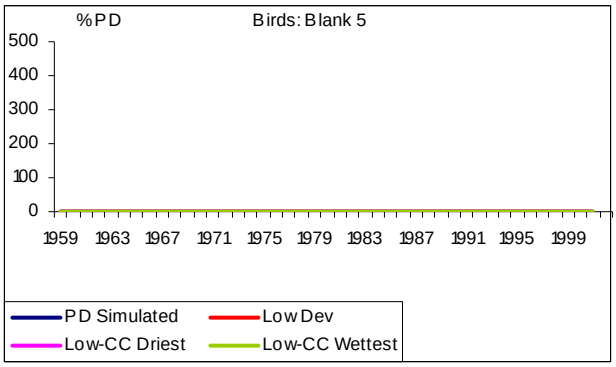
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

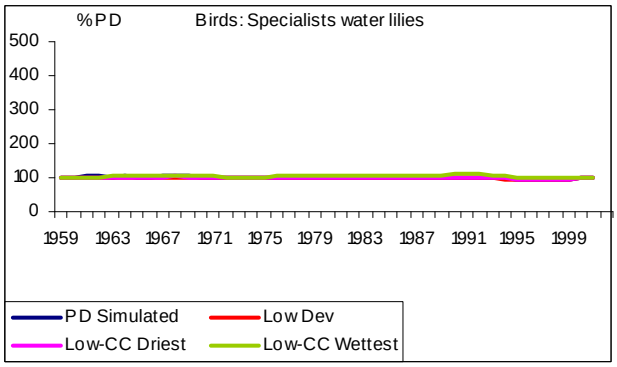
3.7.5 Specialists, water lilies

(Floodplain pools (rising and receding water levels) and lily-pad covered inlets. Essential for feeding habitat)- African and Lesser Jacanas

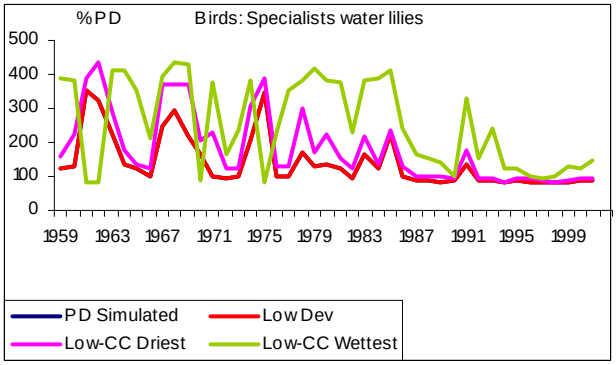
Site 1: Cubango River @ Capico



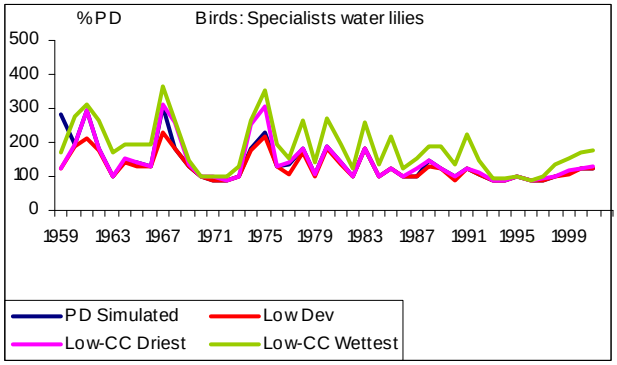
Site 2: Cubango River @ Mucundi



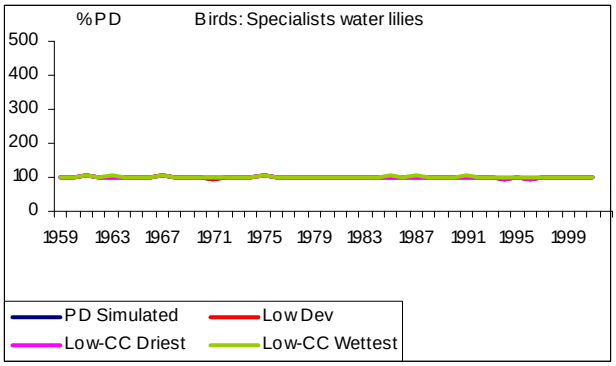
Site 3: Cuito River @ Cuito Cuanavale



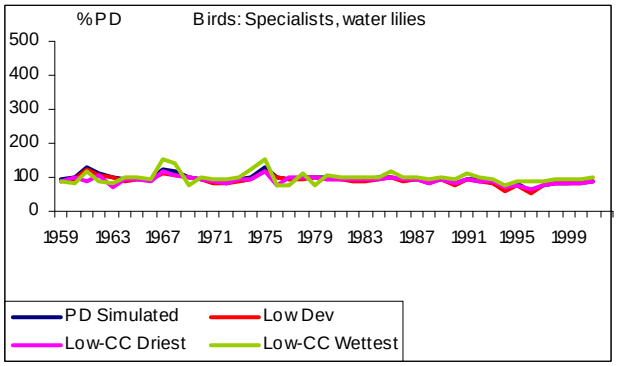
Site 4: Okavango River @ Rundu



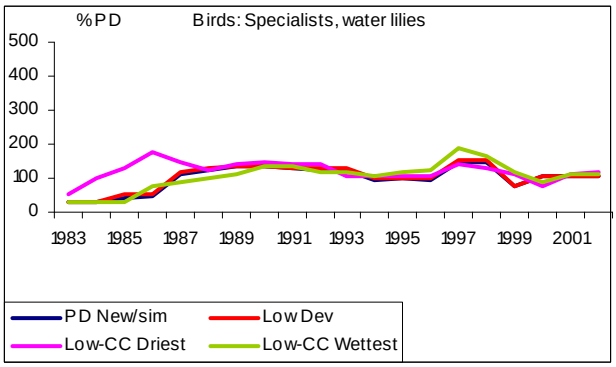
Site 5: Okavango River @ Popa Falls



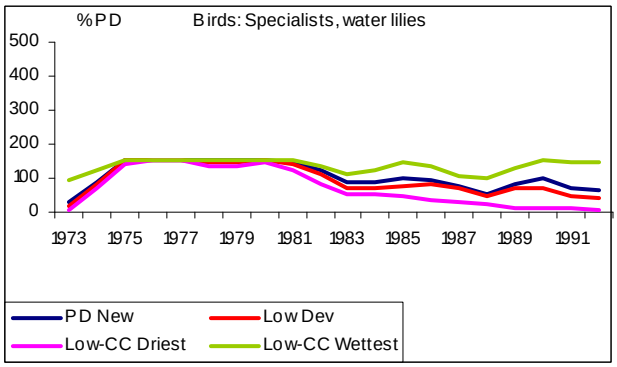
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

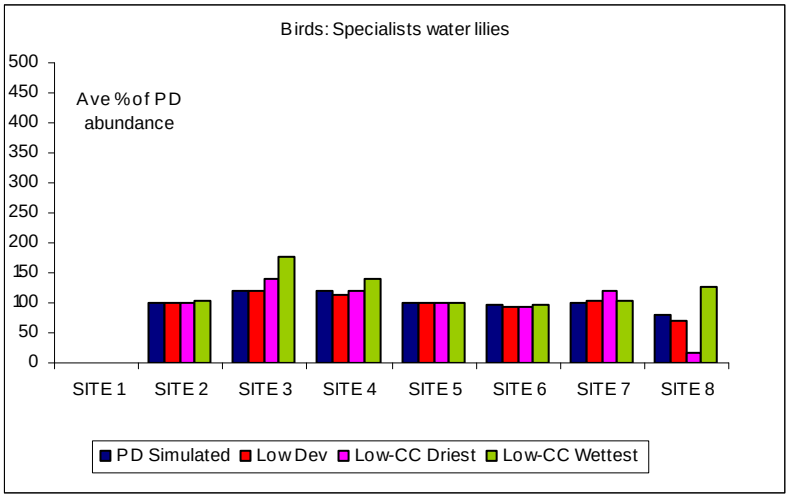


Site 8: Boteti River



Summary change per scenario

Whatever the flood regime, pockets of water lilies generally survive in backwaters, lagoons or isolated pools, providing suitable habitat for these birds.



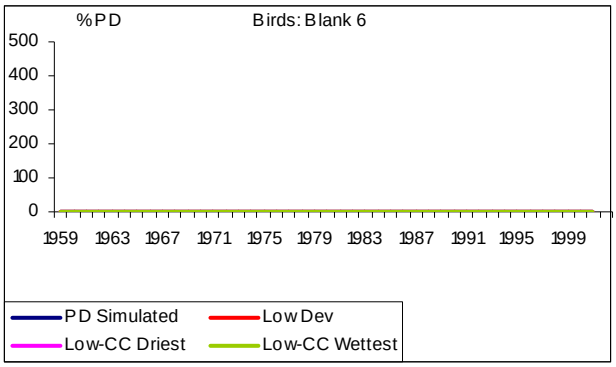
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

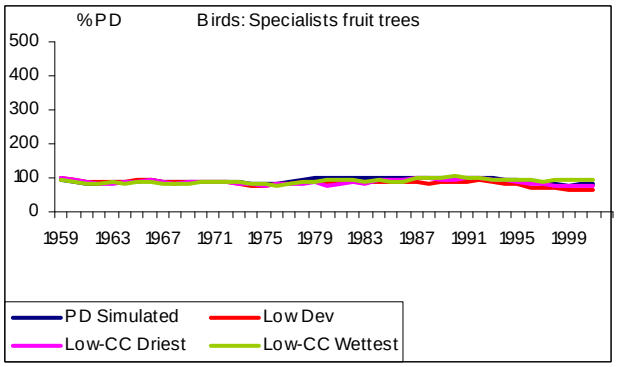
3.7.6 Specialists, fruit trees

(The Specialists, fruit trees category refers to specialist frugivores in riparian fruit trees. The response from the birds should mirror to some extent that for the plants (riparian trees) since if the riparian trees die due to low flows, there will not be a source of food for the birds When riverine fruit trees are in fruit they are an important food source for a large variety of birds.)- Turacos, bulbuls

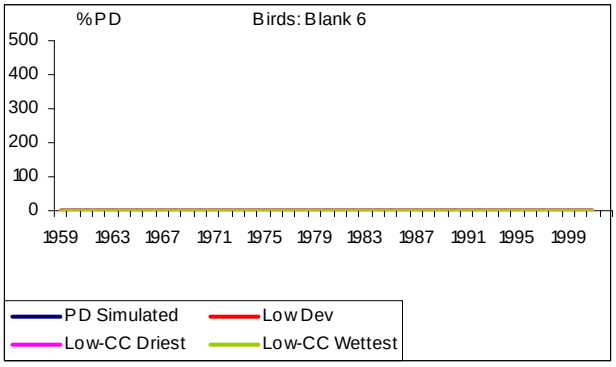
Site 1: Cubango River @ Capico



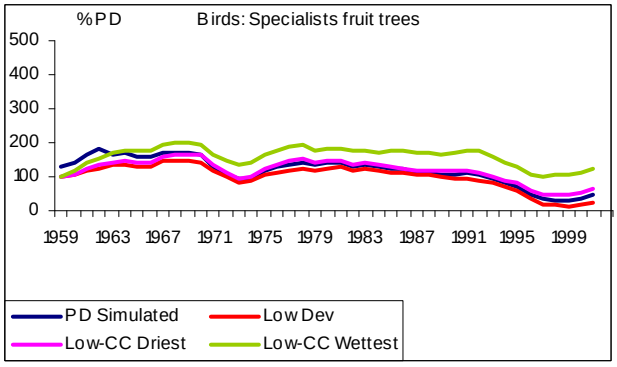
Site 2: Cubango River @ Mucundi



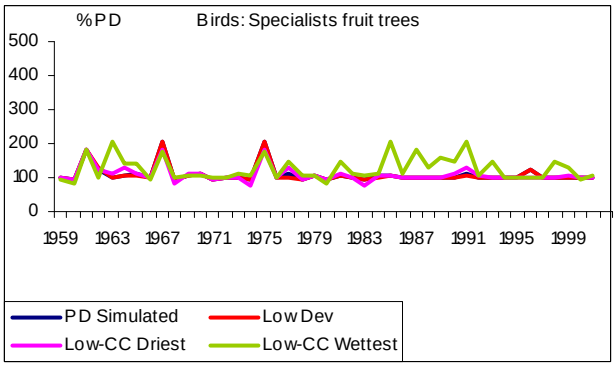
Site 3: Cuito River @ Cuito Cuanavale



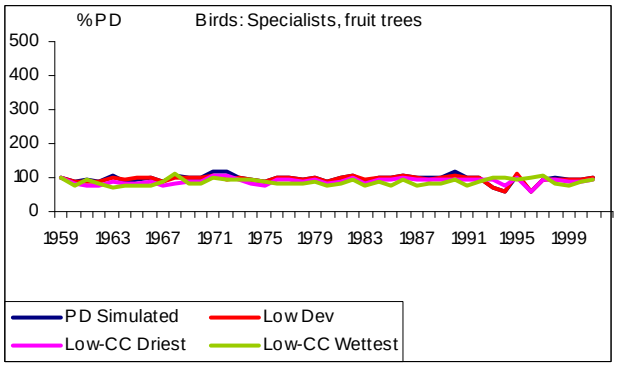
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

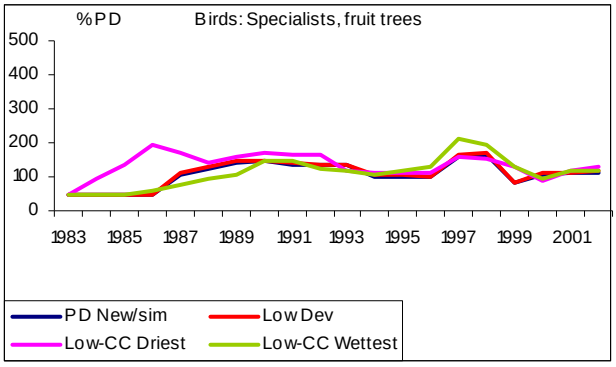


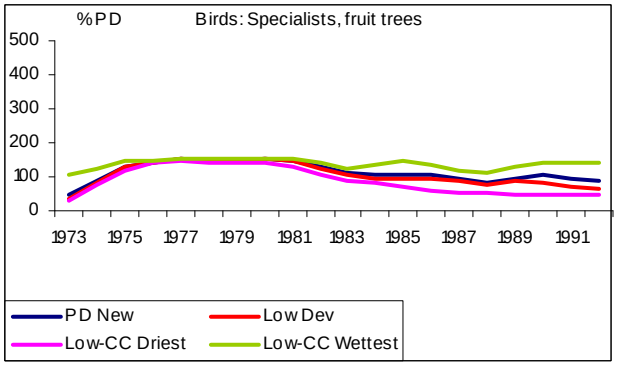
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

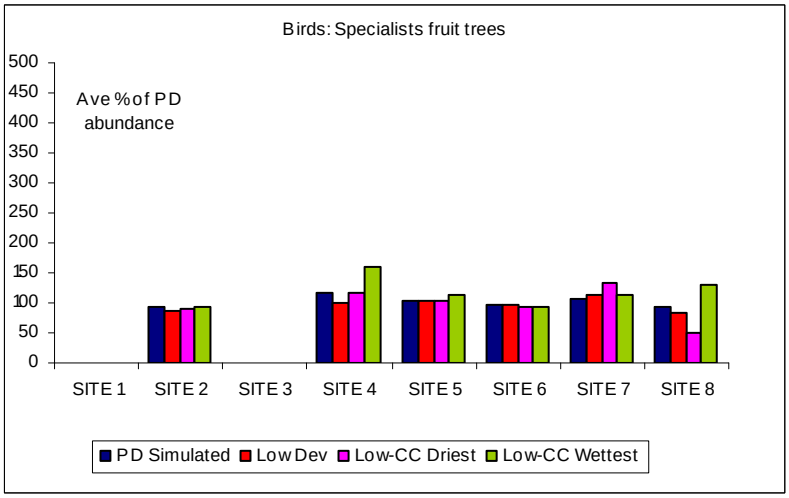
Site 8: Boteti River





Summary change per scenario

These birds will only be indirectly influenced by changes in water flows i.e. they depend on fruit bearing riparian trees that respond to changes in water flows. Because most of these tress are long-lived, there will be a time lag of several years before fruit production will fail when trees start dying from lack of water.



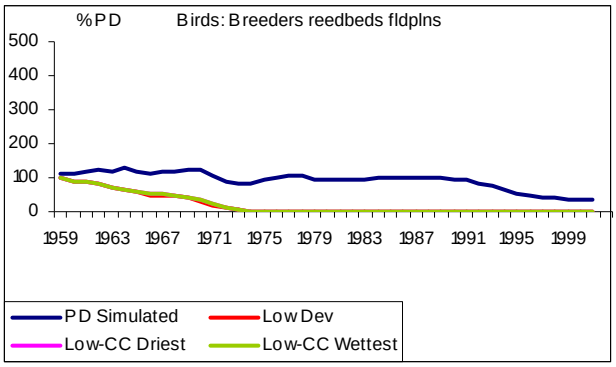
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

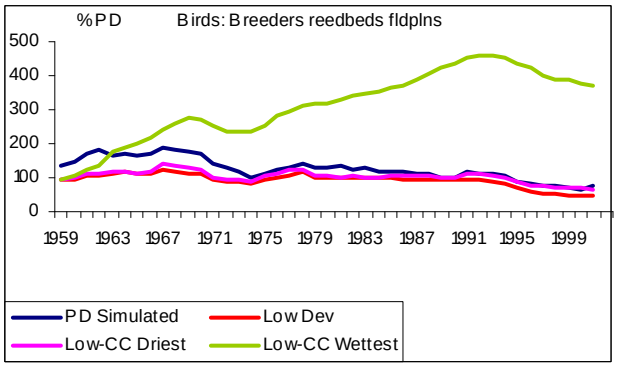
3.7.7 Breeders, reedbeds and fldplns

(Nesting habitat in reedbeds lining river banks and islands.)- Fan-tailed Widowbird, weavers, bishops, herons and egrets

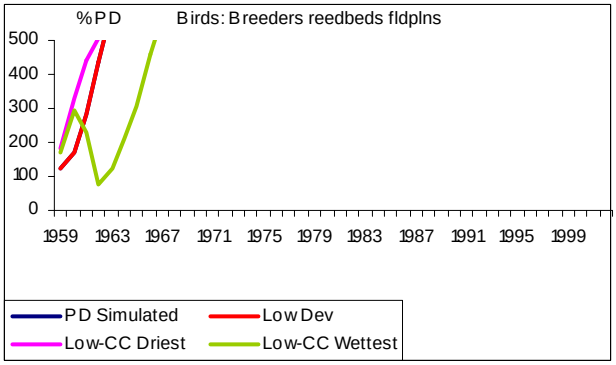
Site 1: Cubango River @ Capico



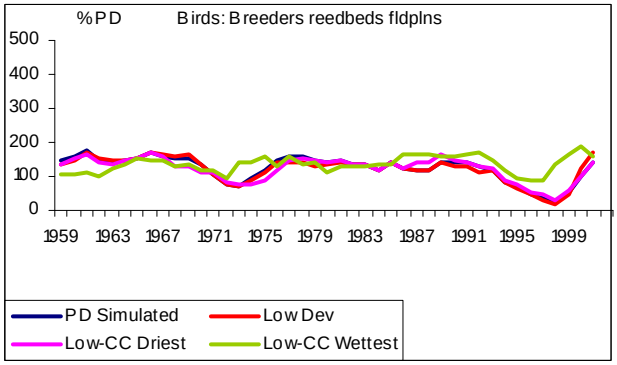
Site 2: Cubango River @ Mucundi



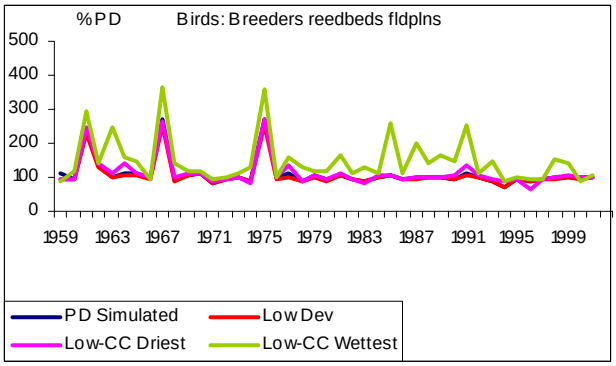
Site 3: Cuito River @ Cuito Cuanavale



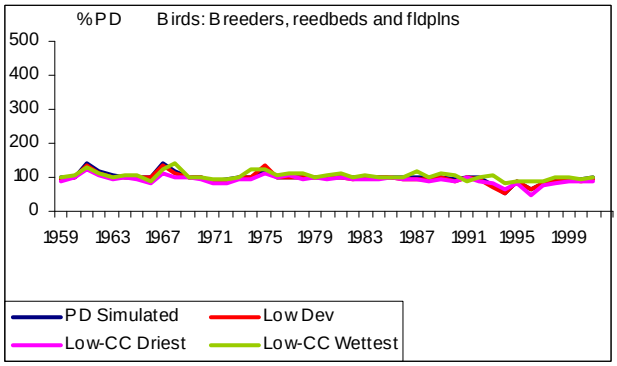
Site 4: Okavango River @ Rundu



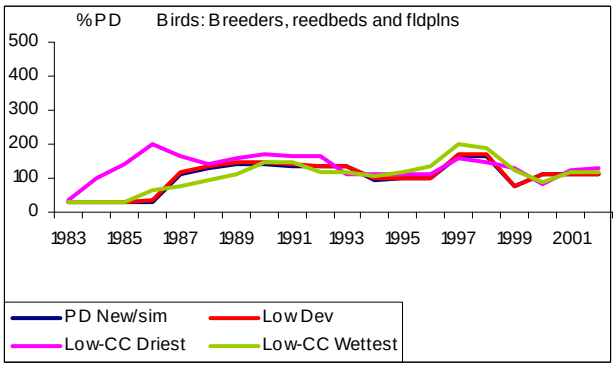
Site 5: Okavango River @ Popa Falls



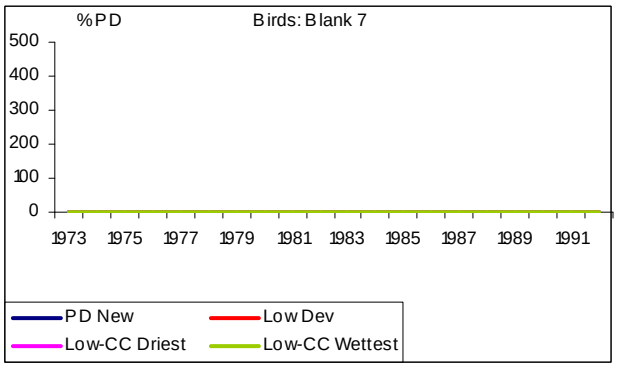
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

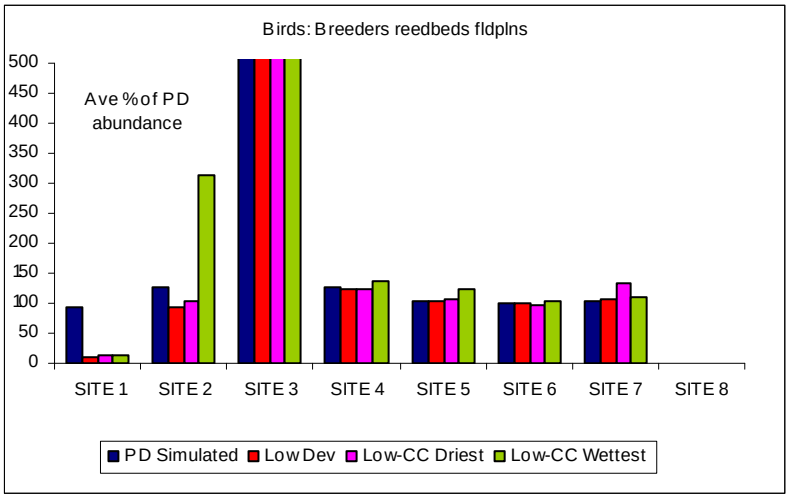


Site 8: Boteti River



Summary change per scenario

These birds must have reedbeds and other vegetation standing in water, in which to build nests as a protective mechanism against predator access to their nests. Therefore, these birds generally wait for optimal high water leves before constructing nests so that nest flooding does not occur by rising waters, and the water level persists throughout the breeding cycle.



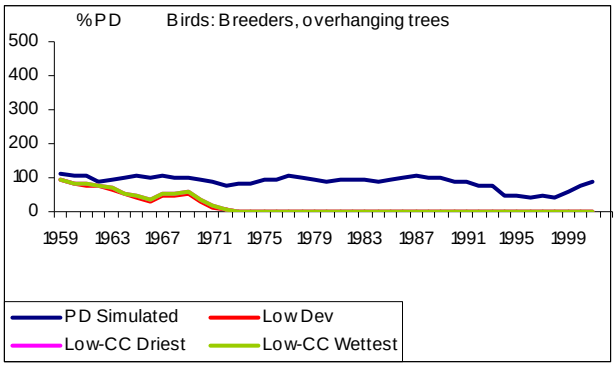
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

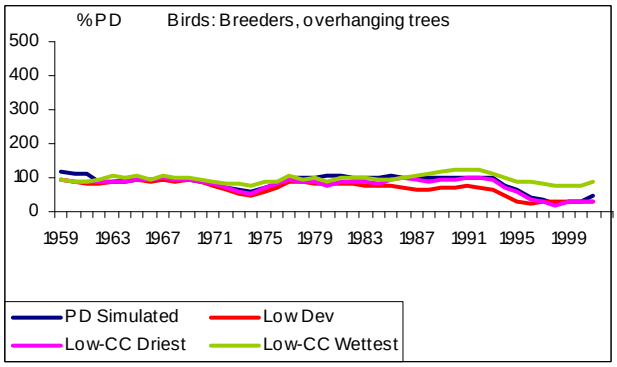
3.7.8 Breeders, overhanging trees

(Colonial breeders or solitary nesters requiring over-hanging vegetation for nest safety or fledglings vacating the nest)- Herons, cormorants, darters

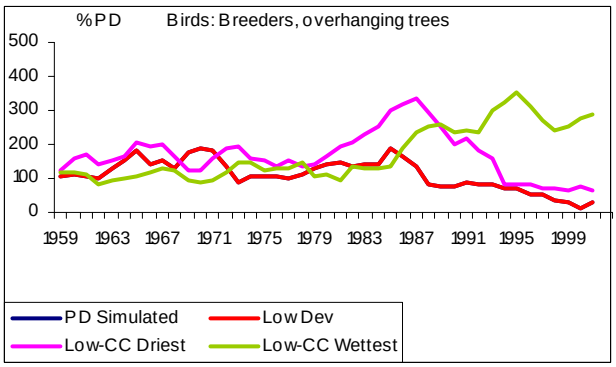
Site 1: Cubango River @ Capico



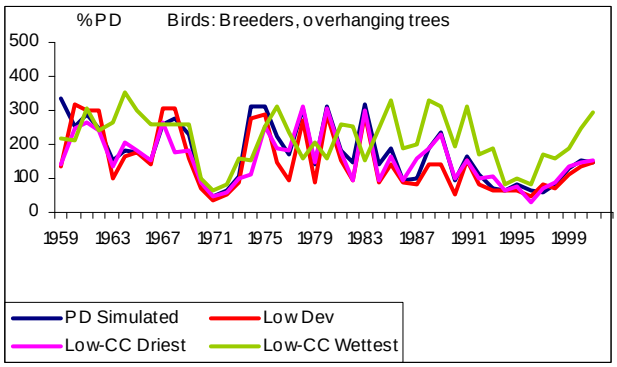
Site 2: Cubango River @ Mucundi



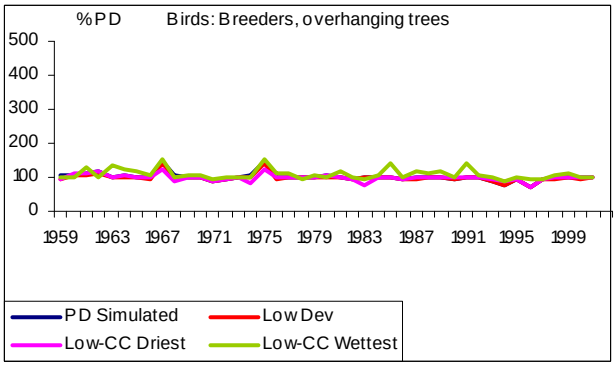
Site 3: Cuito River @ Cuito Cuanavale



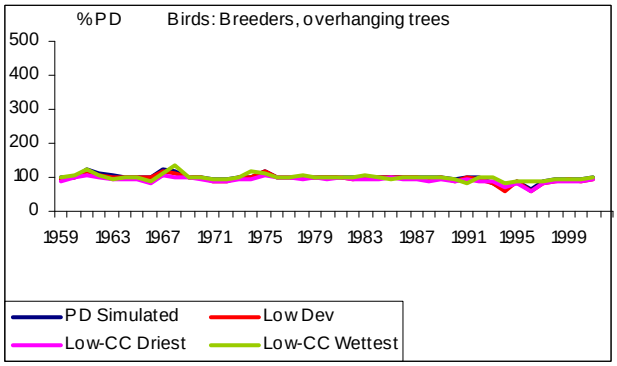
Site 4: Okavango River @ Rundu



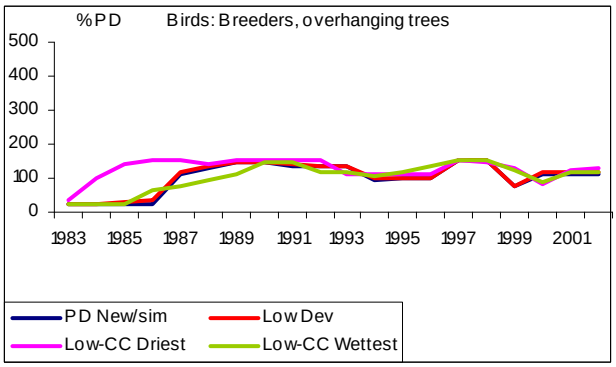
Site 5: Okavango River @ Popa Falls



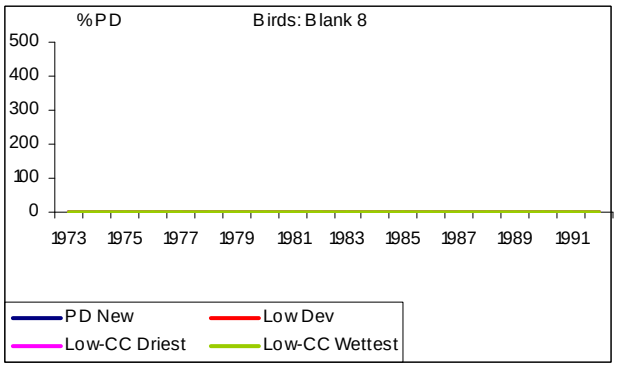
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

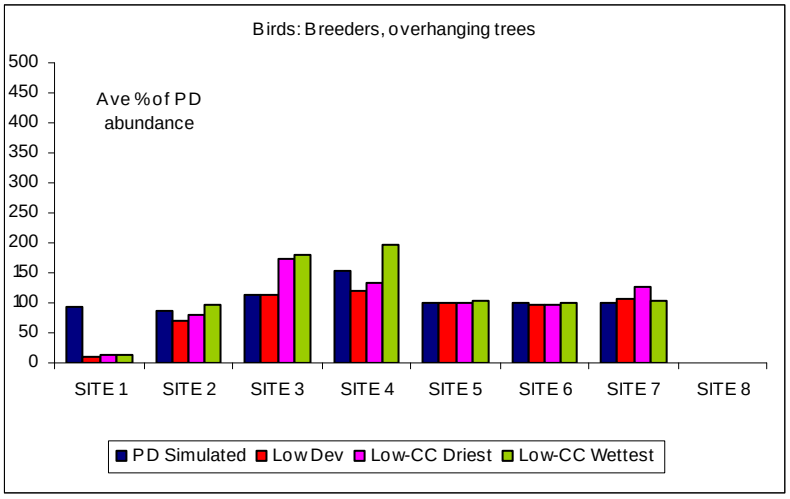


Site 8: Boteti River



Summary change per scenario

Trees overhanging water are critical to the breeding success of these birds for two reasons: protection against predators, and for refuge by chicks when disturbed.



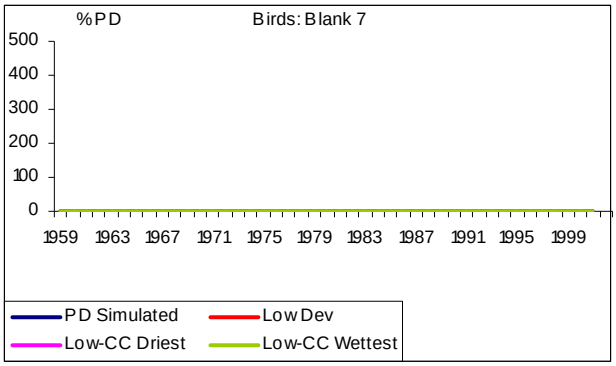
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

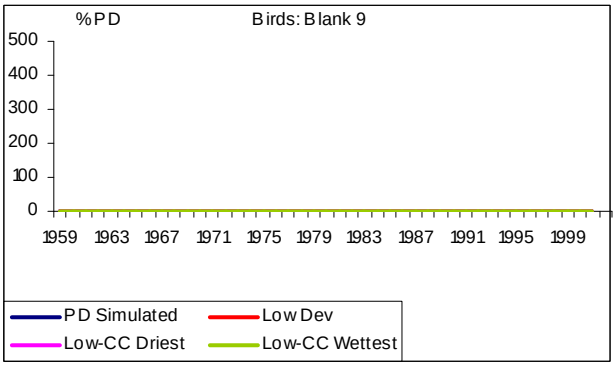
3.7.9 Breeders, banks

(Require vertical banks for nest holes or the grassy banks for nest sites and fledgling development (Note that kingfishers have been excluded))- Bee-eaters, Collared Pratincoles, lapwings

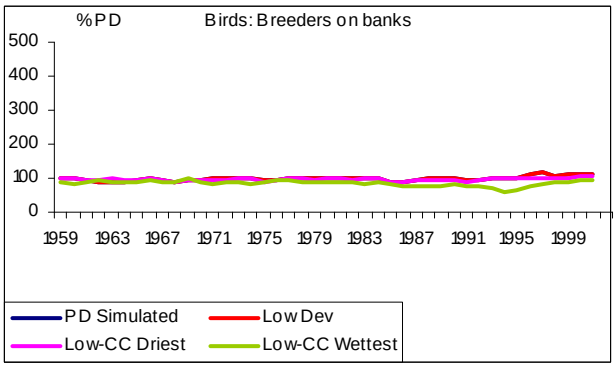
Site 1: Cubango River @ Capico



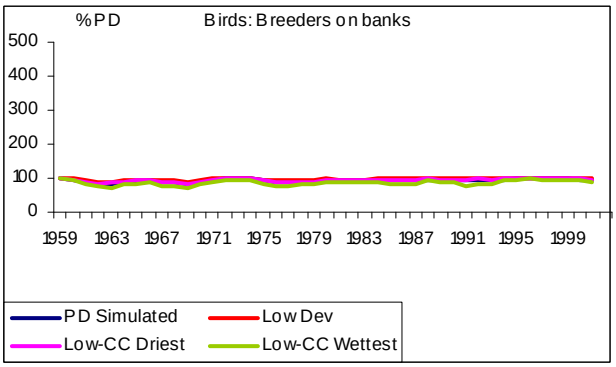
Site 2: Cubango River @ Mucundi



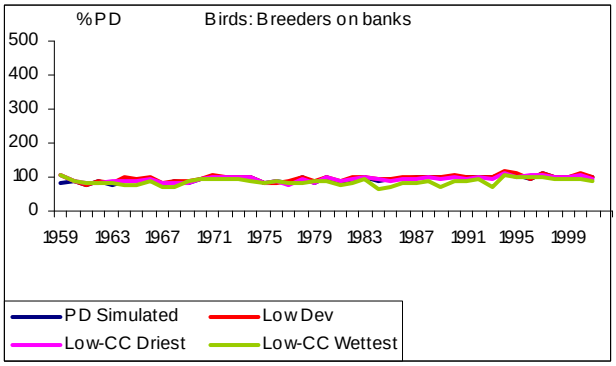
Site 3: Cuito River @ Cuito Cuanavale



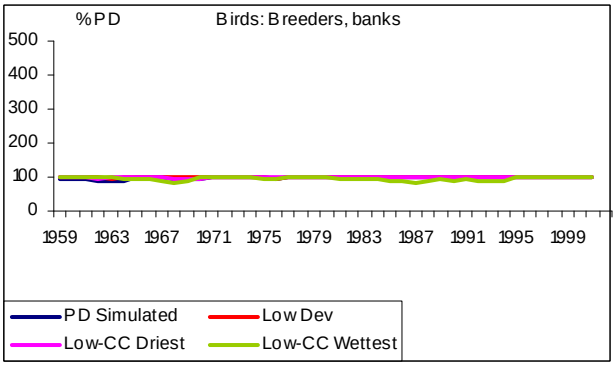
Site 4: Okavango River @ Rundu



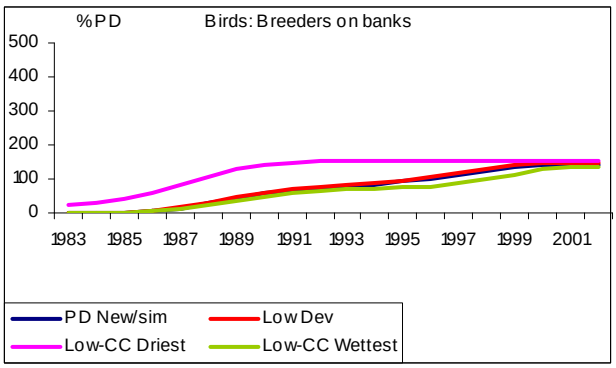
Site 5: Okavango River @ Popa Falls



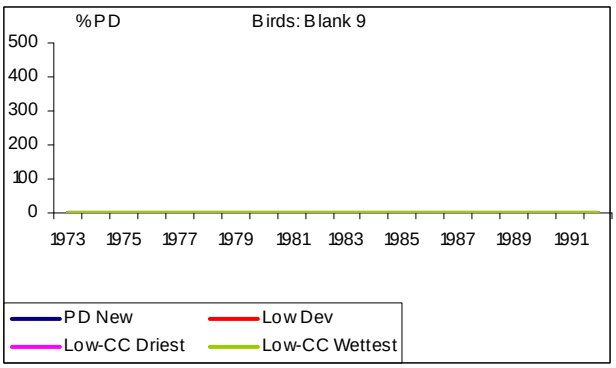
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

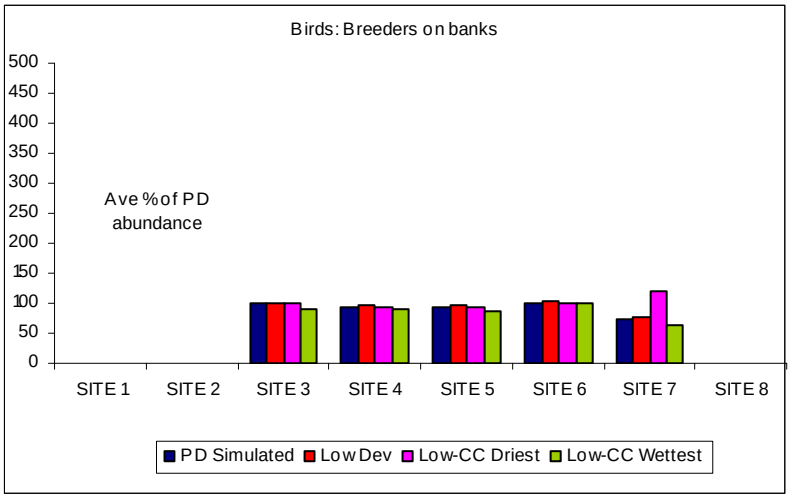


Site 8: Boteti River



Summary change per scenario

These birds are influenced only by reliably lowering water levels to expose vertical or grassy banks for breeding purposes - they are not necessarily dependent on the river flow for their food supply.



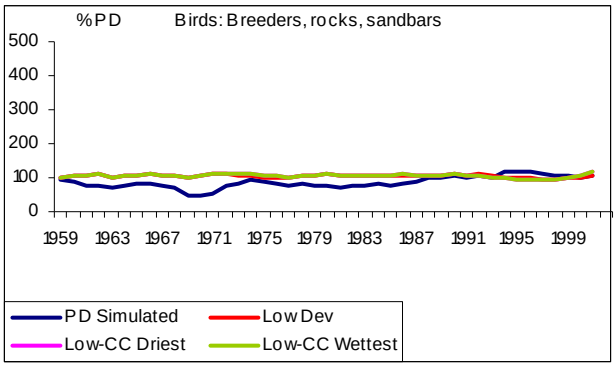
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

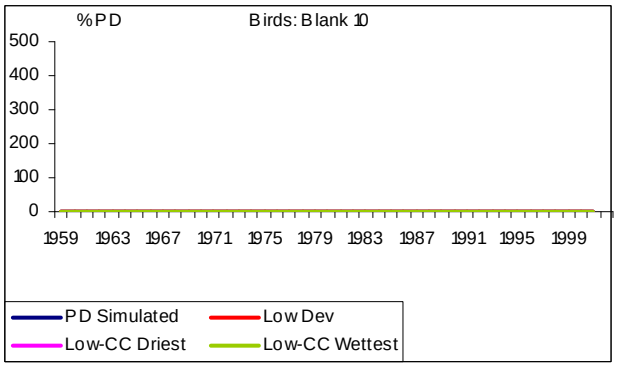
3.7.10 Breeders, rocks, sandbars

(Totally dependent on emerged rocks, sandbars and islands in the main river for nesting purposes)- Rock Pratincole, African Skimmer, sandpipers, thick-knees

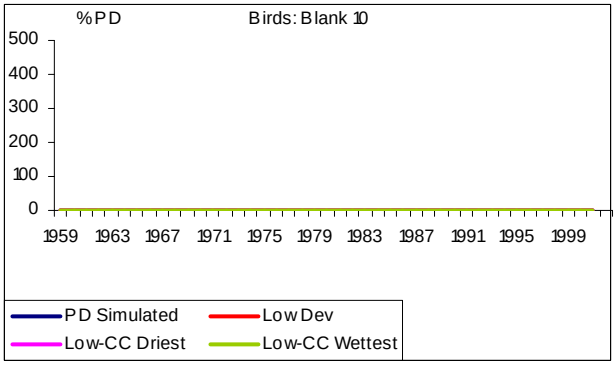
Site 1: Cubango River @ Capico



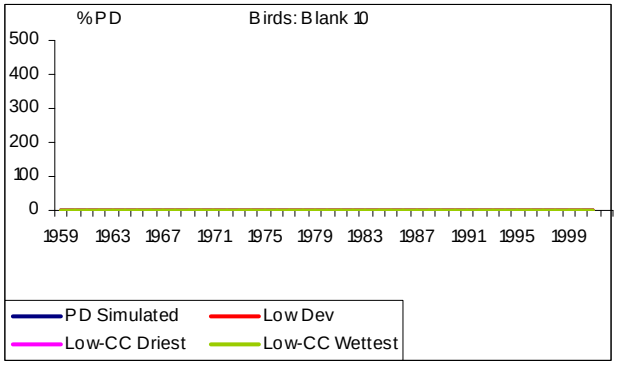
Site 2: Cubango River @ Mucundi



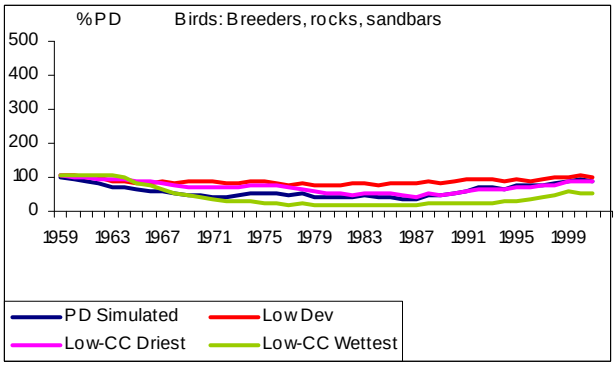
Site 3: Cuito River @ Cuito Cuanavale



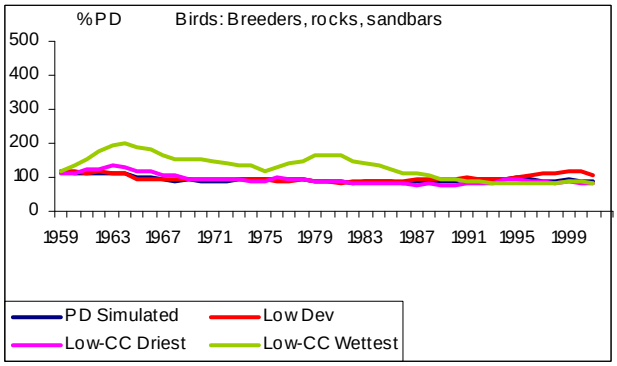
Site 4: Okavango River @ Rundu



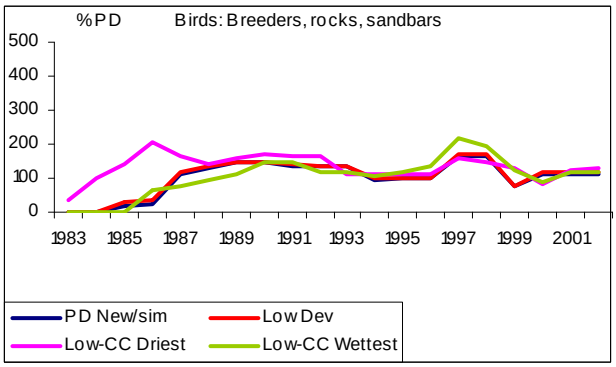
Site 5: Okavango River @ Popa Falls



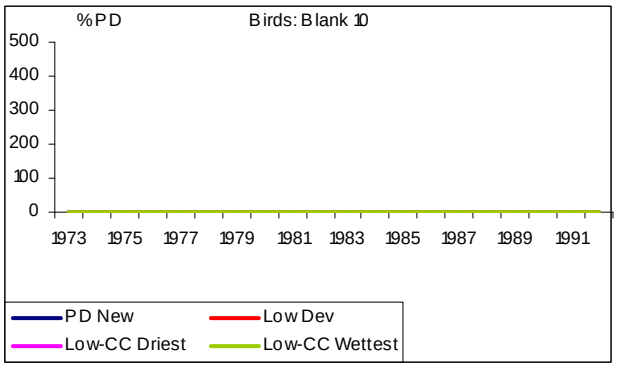
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

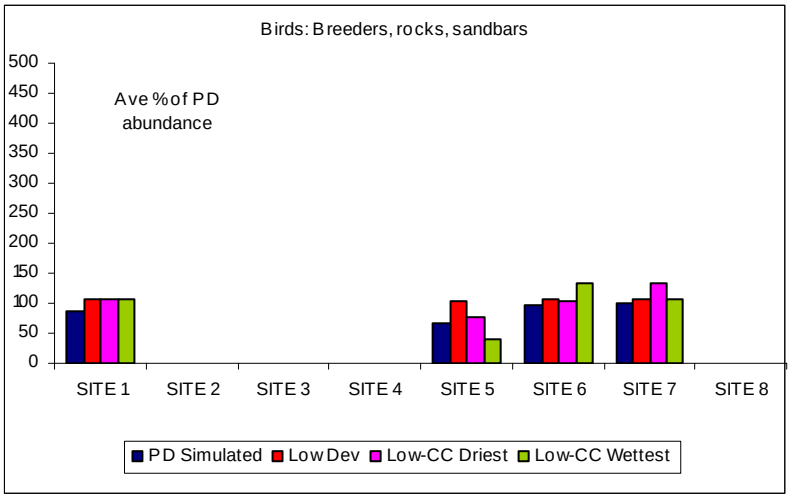


Site 8: Boteti River



Summary change per scenario

Low flow levels generally benefit these birds as this is the time when sandbanks and rocks are exposed for breeding. However, very low flows will result in sandbanks becoming accessible to predators and also negatively affect the food supply for those which eat fish (fish which need to get onto floodplains to breed).



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4. MEDIUM SCENARIO WITH AND WITHOUT CLIMATE CHANGE

4.1. Geomorphology

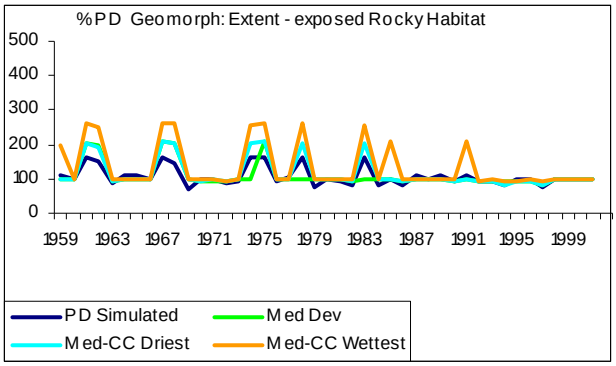
This section provides the time-series of area of geomorphology indicators under the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Extent - exposed rocky habitat
- Extent - coarse sediments
- Cross sectional area of channel
- Extent of backwaters
- Extent of vegetated islands
- Sand bars at low flow
- Percentage clays on floodplain
- Extent of inundated floodplain
- Inundated Pools and Pans
- Extent of cut banksCarbon sequestration.

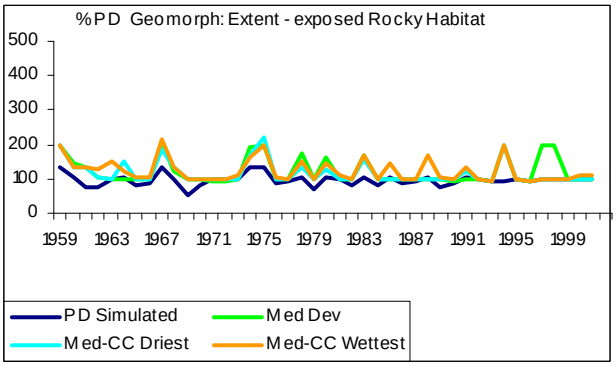
4.1.1 Extent - exposed rocky habitat

(Extent of exposed rocky habitat during the low flow season.)- Not considering the impacts of sediment deposition covering bedrock exposures; only considering the exposed bedrock above the water surface.

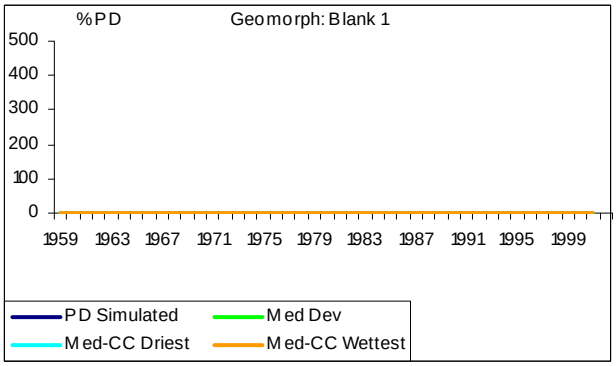
Site 1: Cubango River @ Capico



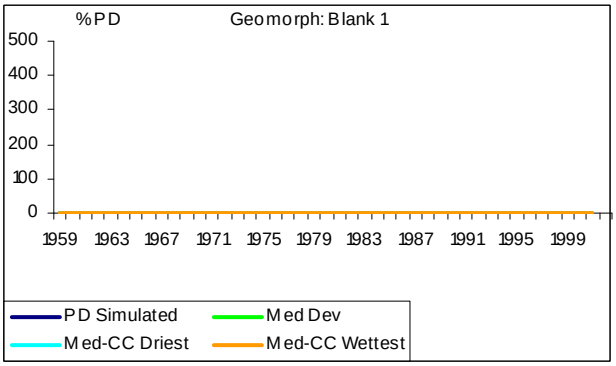
Site 2: Cubango River @ Mucundi



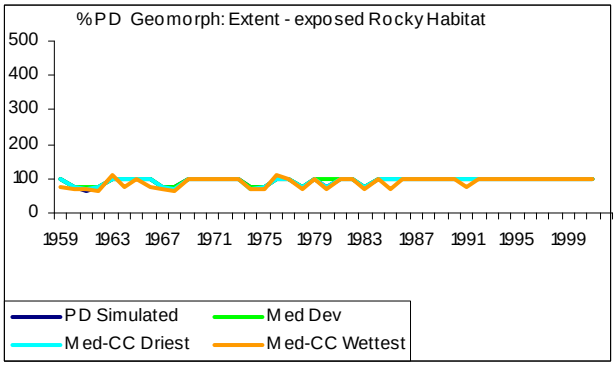
Site 3: Cuito River @ Cuito Cuanavale



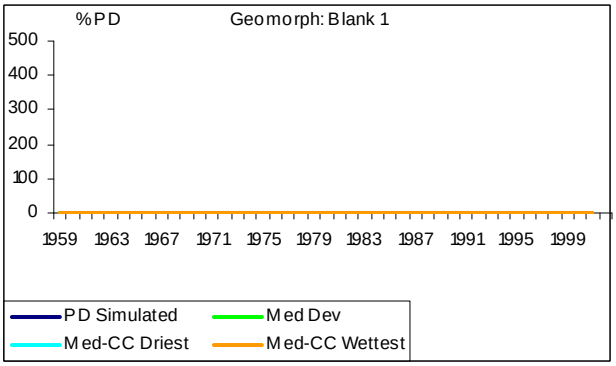
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

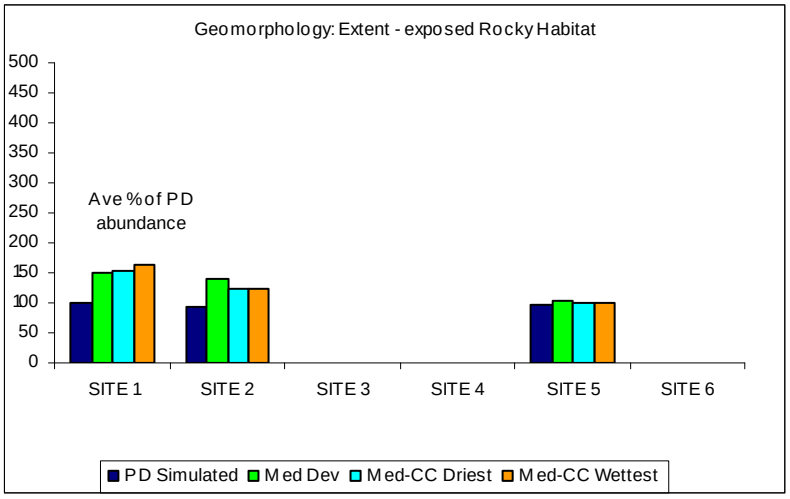


Site 6: Okavango River @ Pan Handle



Summary change per scenario

There is a direct relationship between flow level and rocks exposed above water level. As water level rises, less rocky area is exposed.



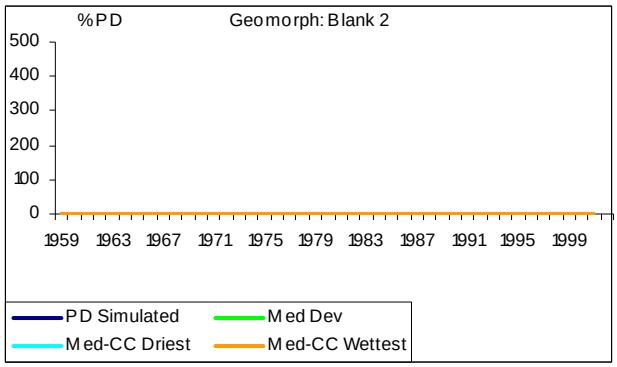
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

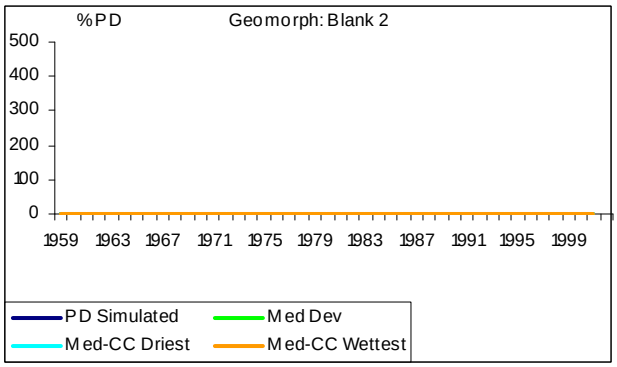
4.1.2 Extent of coarse sediments

(Extent of coarse sediments On The Bed)- The bulk of the sediment load is in the range of particle size 0.25 to 0.4mm. This is fine sand that was originally deposited by wind and later reworked by water. Suspended load is much smaller in volume and consists of silt and clay sized particles.

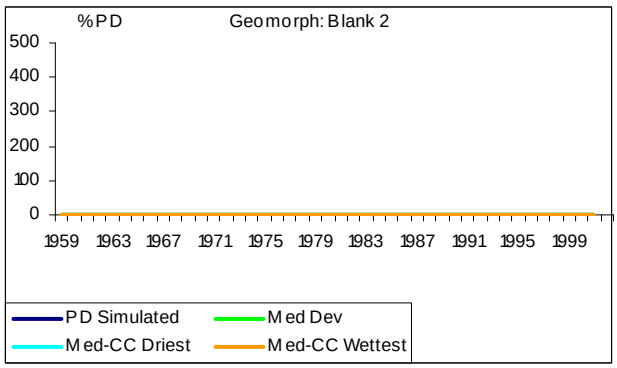
Site 1: Cubango River @ Capico



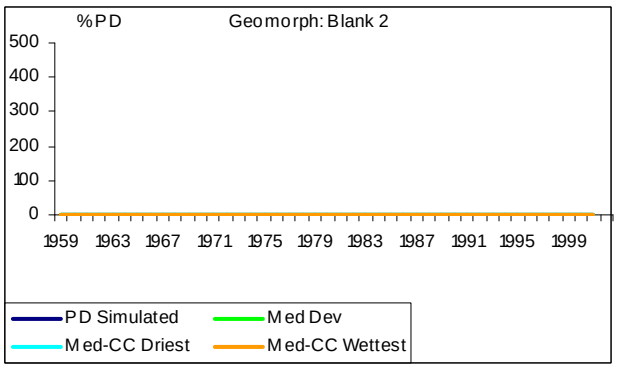
Site 2: Cubango River @ Mucundi



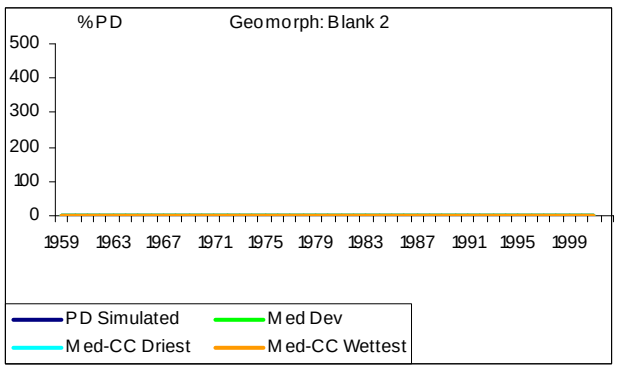
Site 3: Cuito River @ Cuito Cuanavale



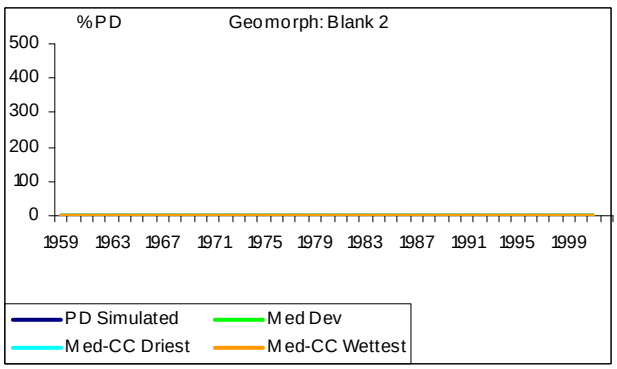
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

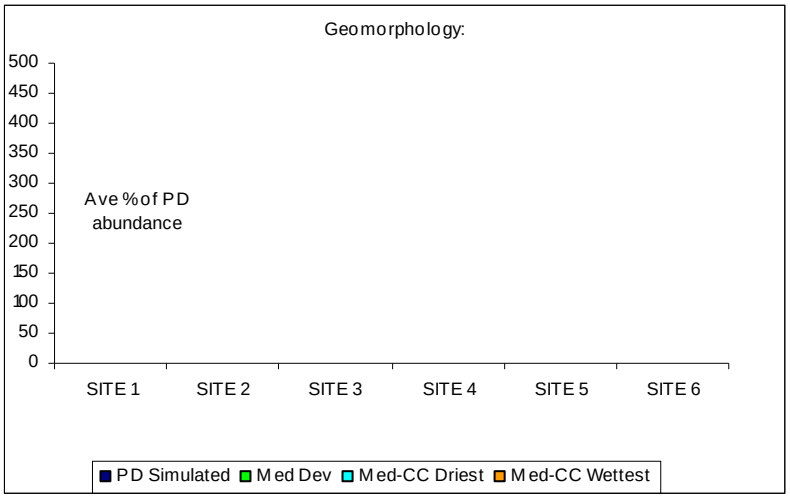


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Sediment (fine sand) is moved as bedload and not in suspension. The rate of flow is proportional to (approximately) the mean flow velocity cubed. The relationship is such that a small decrease in flow velocity results in a large decrease in sediment discharge. Since flow rate is related to flow velocity, as flow rate decreases so sediment discharge will also decrease.



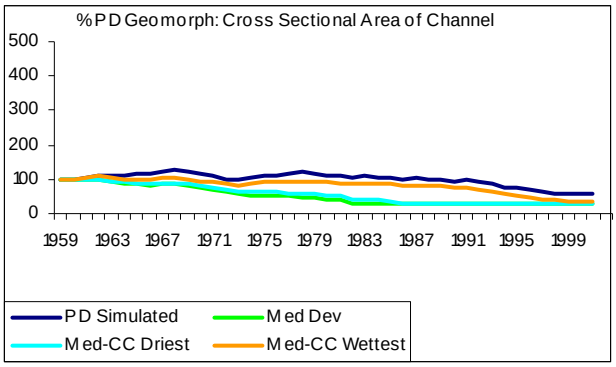
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

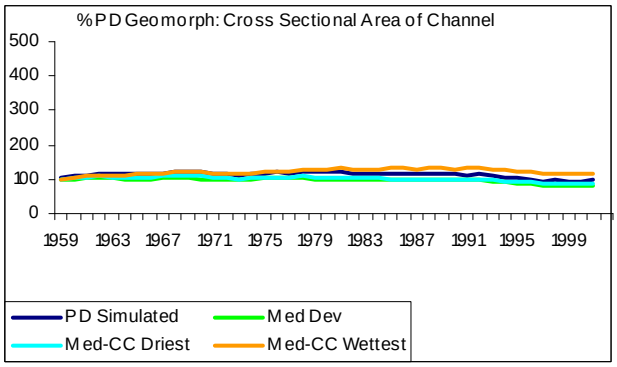
4.1.3 Cross sectional area of channel

(Cross Sectional Area of Bank Full Channel.)- This refers to the well defined channel on aerial photos, which carries the bulk of the flood. It is the perennial channel in present day conditions

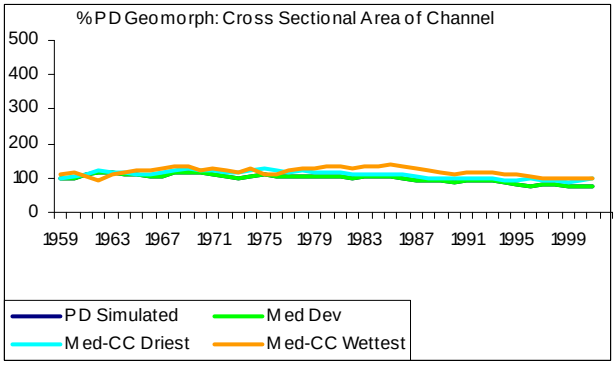
Site 1: Cubango River @ Capico



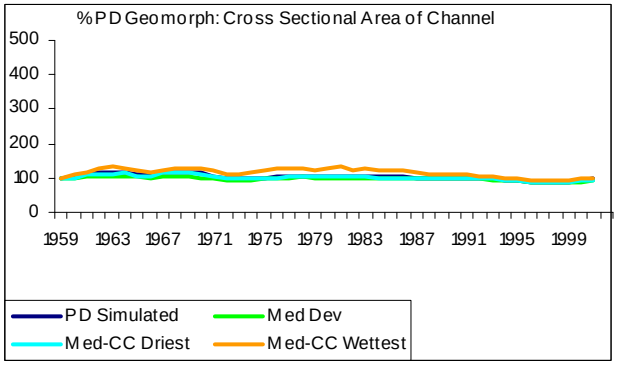
Site 2: Cubango River @ Mucundi



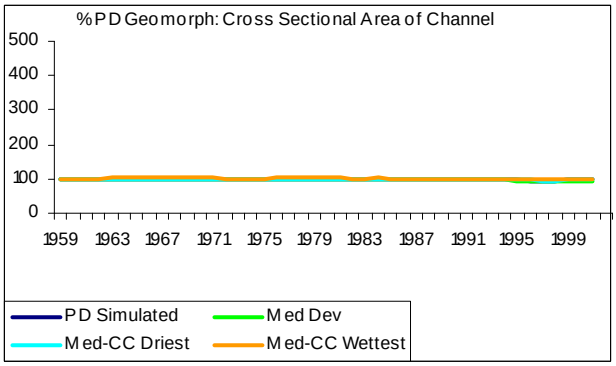
Site 3: Cuito River @ Cuito Cuanavale



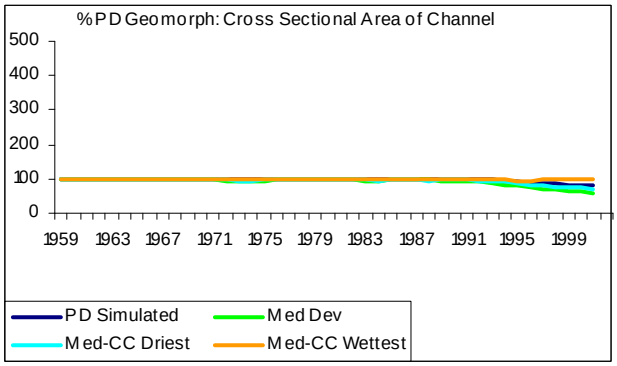
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

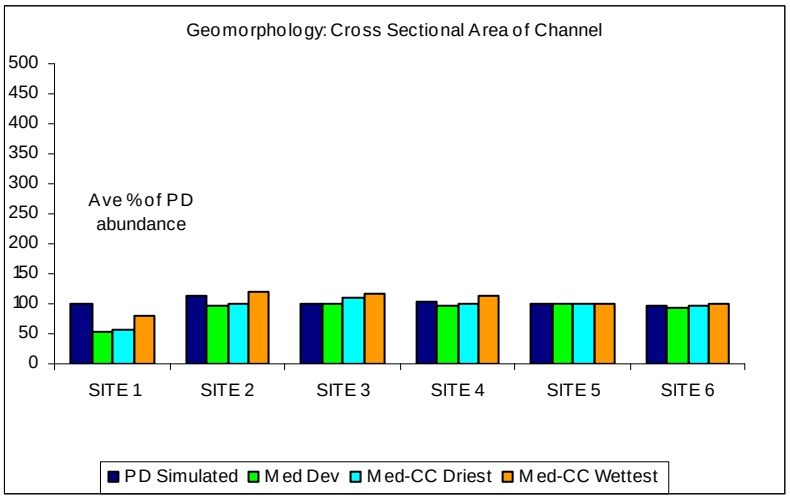


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Channel cross section responds mainly to flood conditions. Floods larger than the historical maximum should rapidly enlarge the cross sectional area. However, the channel also responds to low flow conditions or extended low flow conditions - which enables vegetation to encroach into the channel, trapping sediment, and ultimately reducing the channel cross section. This process is much slower than channel enlargement. However, intervening floods are expected to undo this trend.



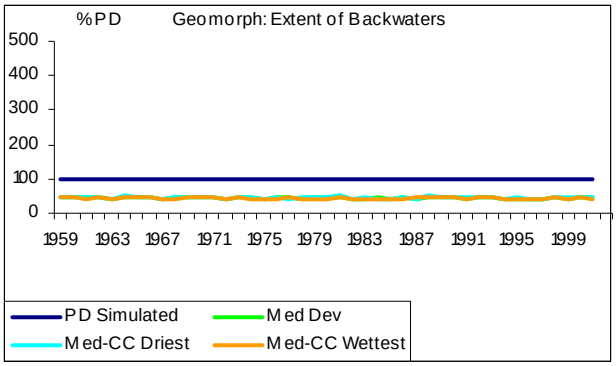
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

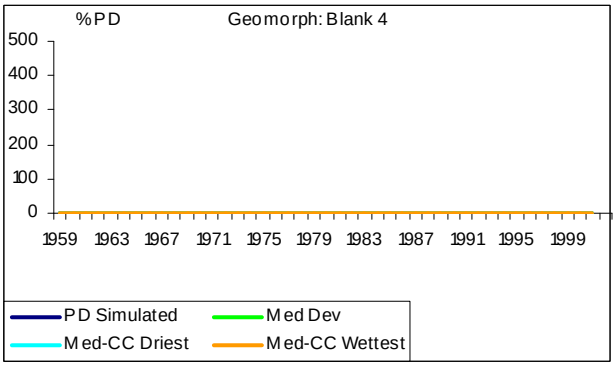
4.1.4 Extent of backwaters

(Extent of (Slow/No Flow) Backwater Areas)- Backwaters are remnants of obsolete channels, which are still connected to the main channel. During the low flow they will fill by water backing up from the river, but during flooding they may also receive water that flows over the floodplain.

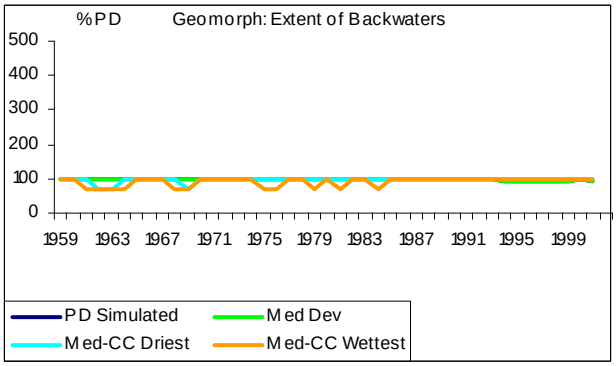
Site 1: Cubango River @ Capico



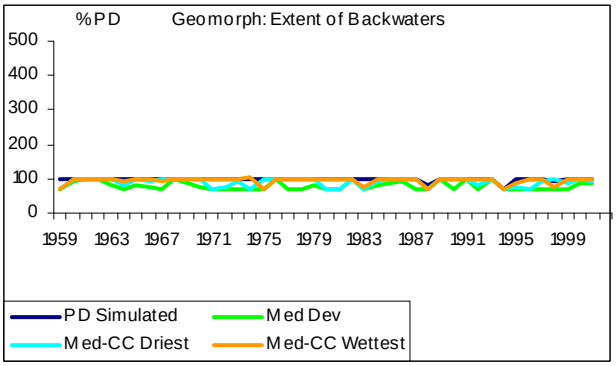
Site 2: Cubango River @ Mucundi



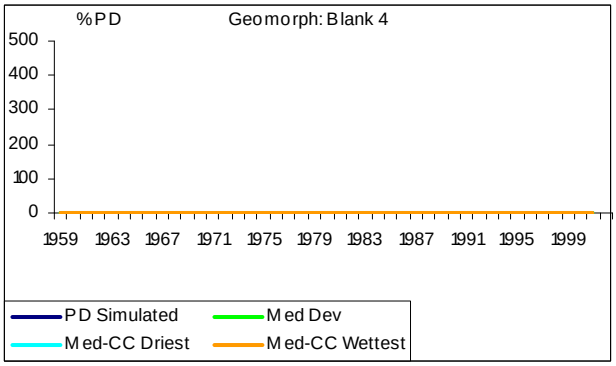
Site 3: Cuito River @ Cuito Cuanavale



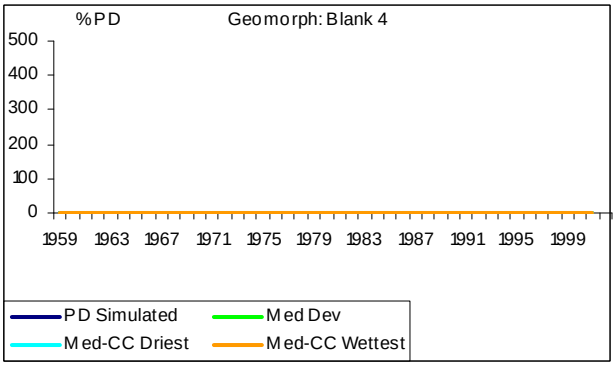
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

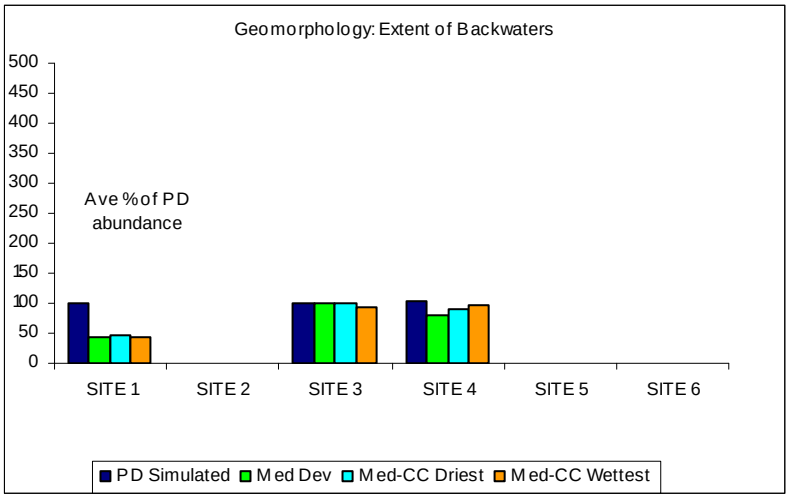


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Filling or emptying of backwaters is directly related to the water level in the river. Backwaters gradually fill with sediment and therefore may be shallower than the main channel - in that case they may empty before the river dries up. The backwaters tend to be steep sided, so the surface area changes little as water depth changes.



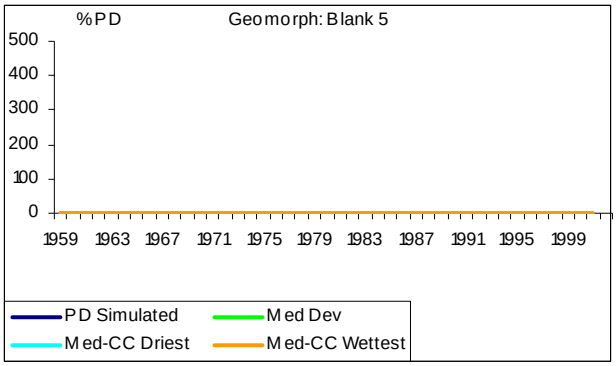
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

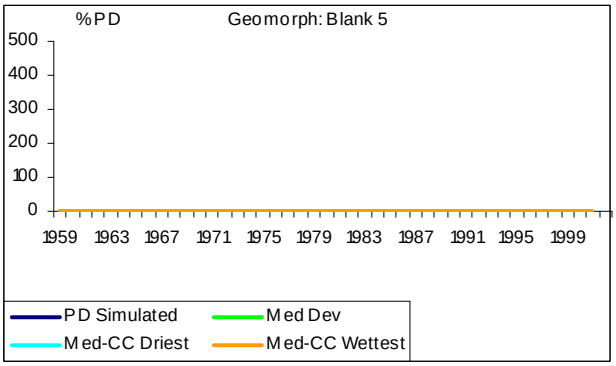
4.1.5 Sand bars at low flow

(Extent of Exposed Sand Bars at Low Flow)- Extensive exposed sand bars exist mainly below the falls. Upriver the sand bars are mostly submerged just below the surface during the low flow season.

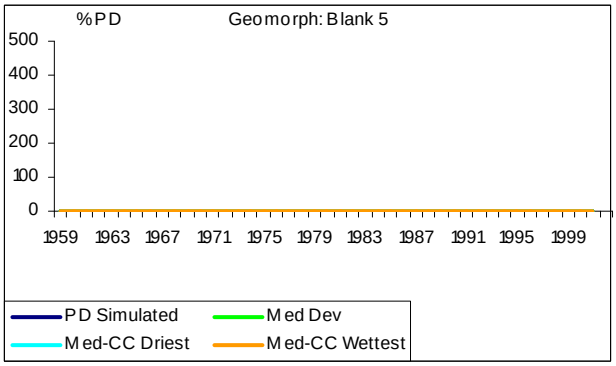
Site 1: Cubango River @ Capico



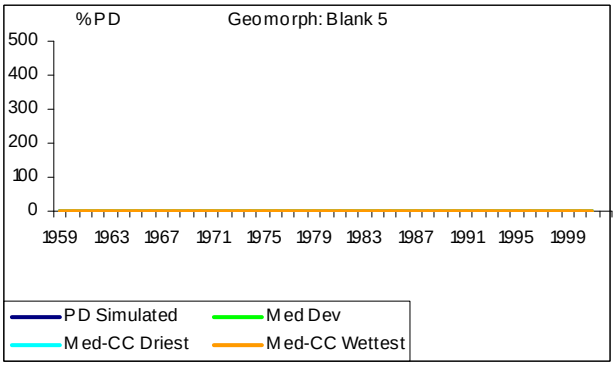
Site 2: Cubango River @ Mucundi



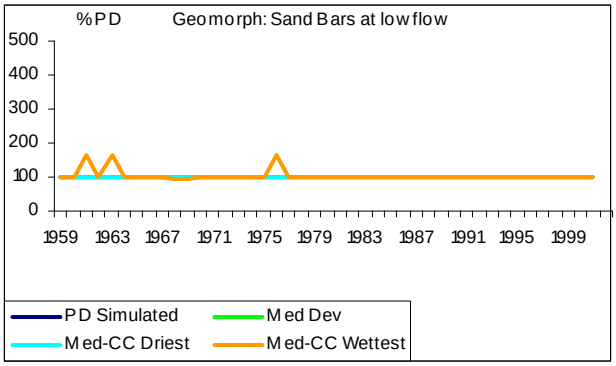
Site 3: Cuito River @ Cuito Cuanavale



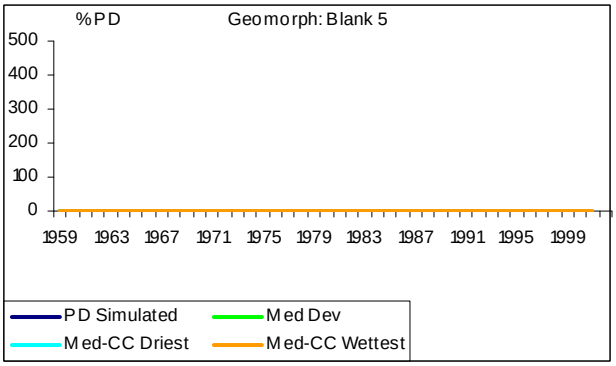
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

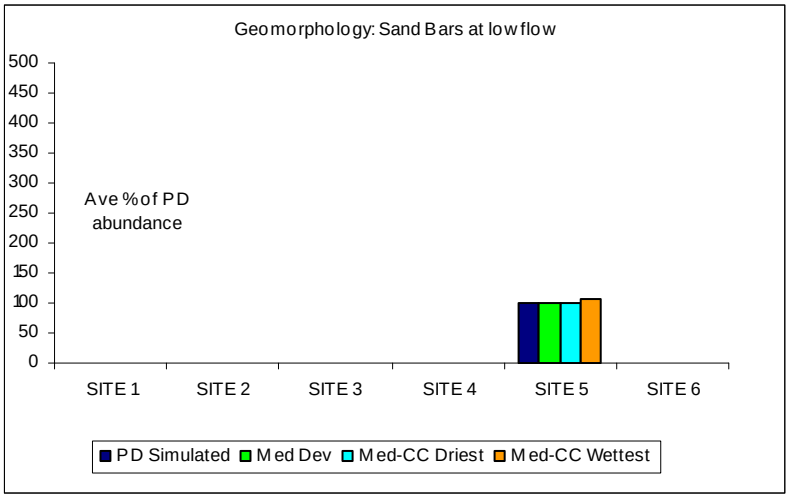


Site 6: Okavango River @ Pan Handle



Summary change per scenario

If one considers only the effect of water flow on sandbanks, then lower flow will expose a greater extent of sandbanks. However, the real issue here is not water but the fact that dams and weirs trap sediment. Downstream of a weir or dam the river is deprived of sediment, so it erodes its bed, banks and floodplains until it is once again carrying its maximum load. Thus, for some distance downstream of a weir or dam the sandbanks will be removed.



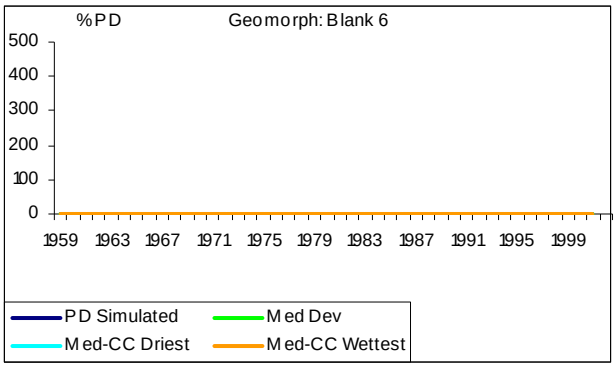
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

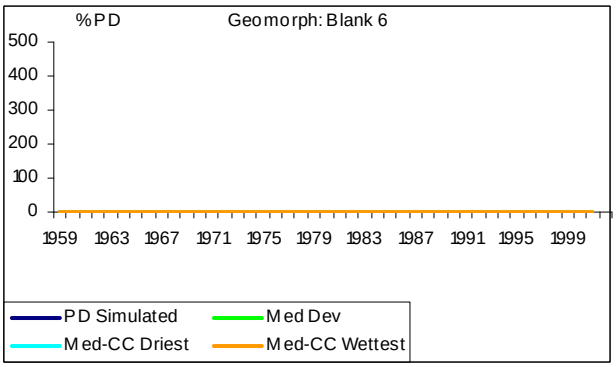
4.1.6 Extent of vegetated islands

(Extent of vegetated islands)- Vegetated islands in the Mukwe-Andara-Popa Falls section of the river (and upstream) are normally comprised of sand on bedrock. Grass, reeds, bush and trees stabilise the sand by reducing wash away during above-average high flows and also promoting deposition of more sand during overtopping of the island.

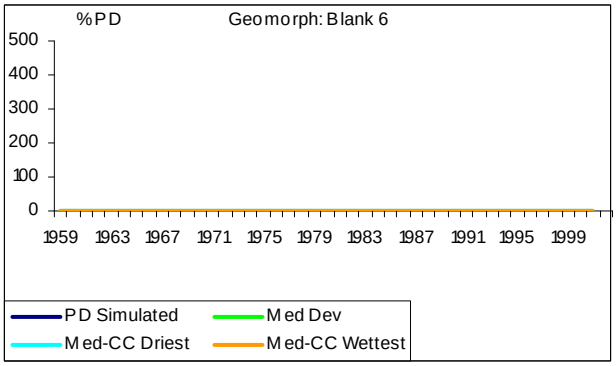
Site 1: Cubango River @ Capico



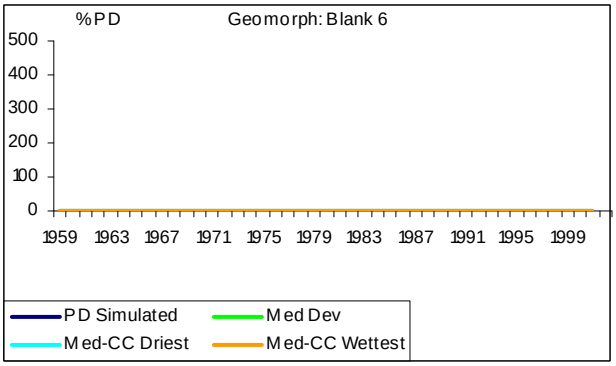
Site 2: Cubango River @ Mucundi



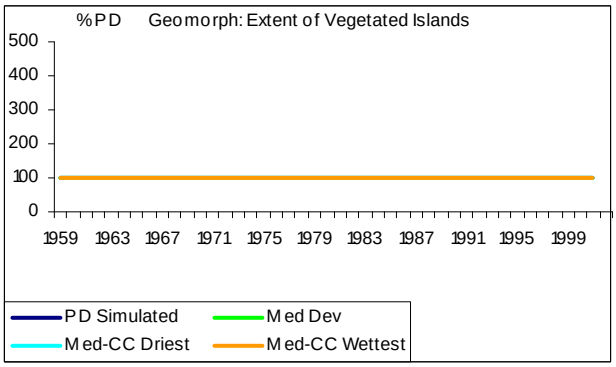
Site 3: Cuito River @ Cuito Cuanavale



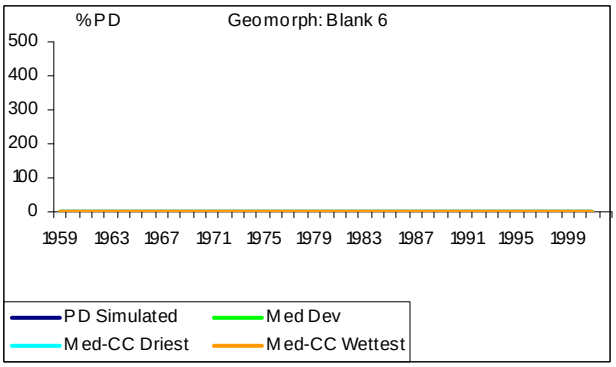
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

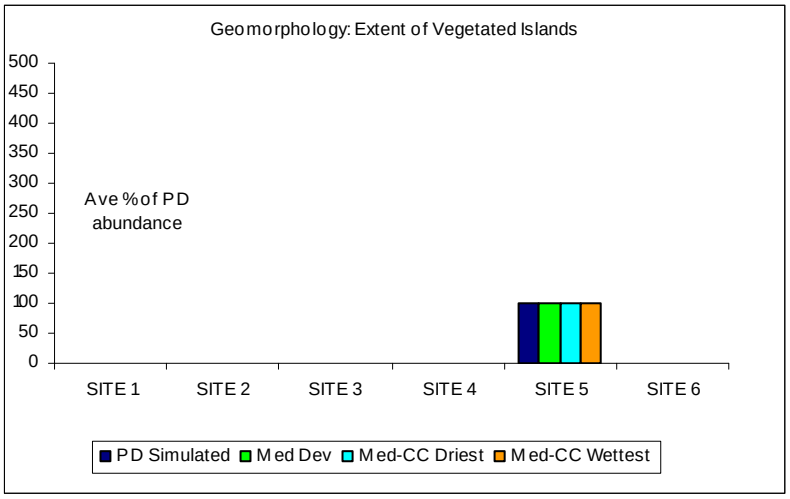


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Reduced flows have little impact on vegetated islands as long as the plants there still get enough water to survive and regenerate themselves. Excessively high floods, however, are likely to cause erosion of the margins of islands. In many cases this erosion is limited to the margins because of the bedrock base to the island.



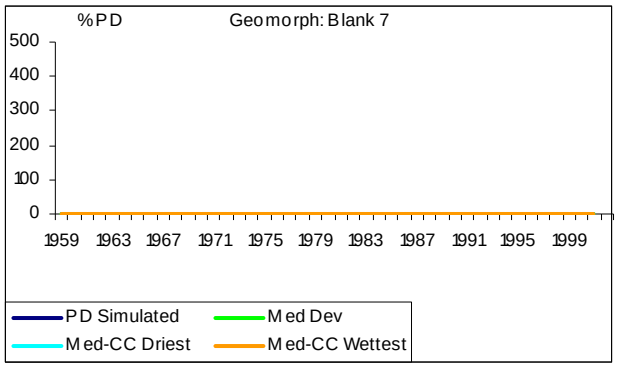
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

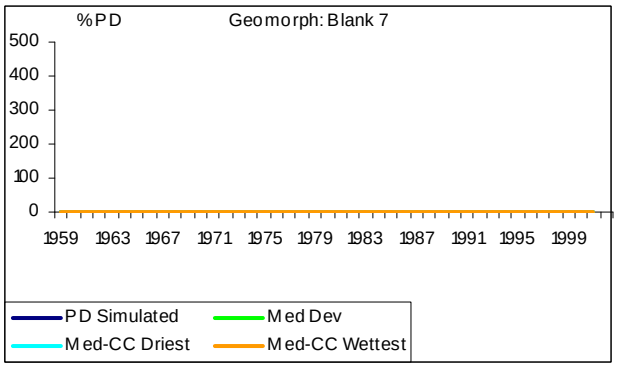
4.1.7 Percentage clays on floodplain

(Percentage Silt & Clays in the top 300mm of the Floodplain)- Floodplains are made predominantly of fine sand, but there is a small amount of silt and clay-sized particles, which are also deposited by the river. The silt and clay is significant for agriculture because it helps to retain moisture and nutrients.

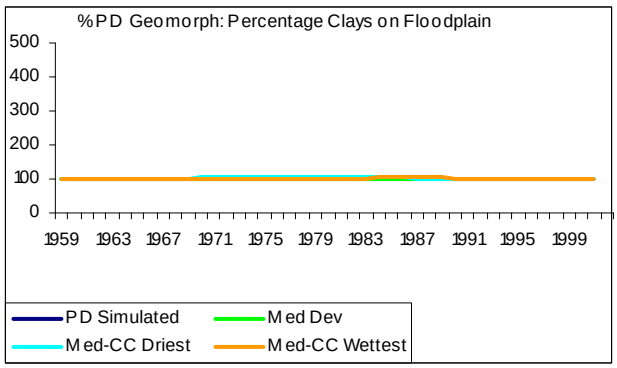
Site 1: Cubango River @ Capico



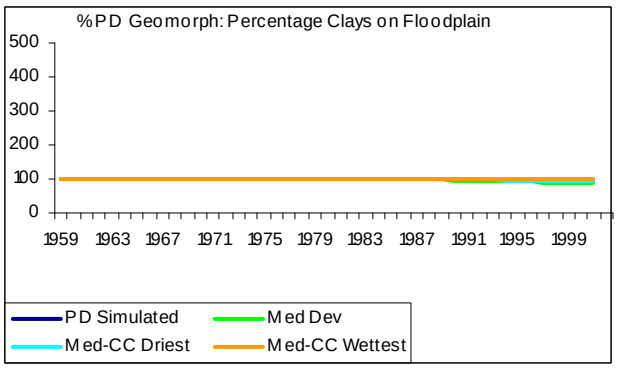
Site 2: Cubango River @ Mucundi



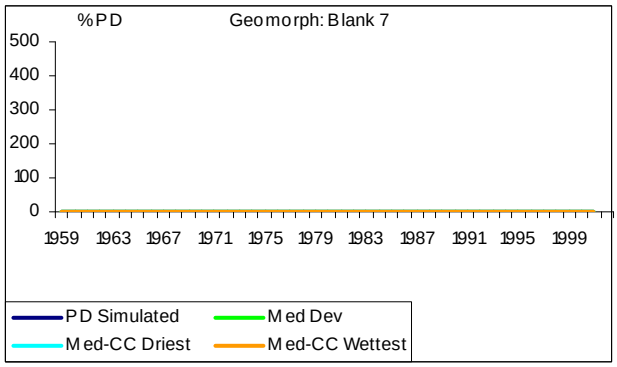
Site 3: Cuito River @ Cuito Cuanavale



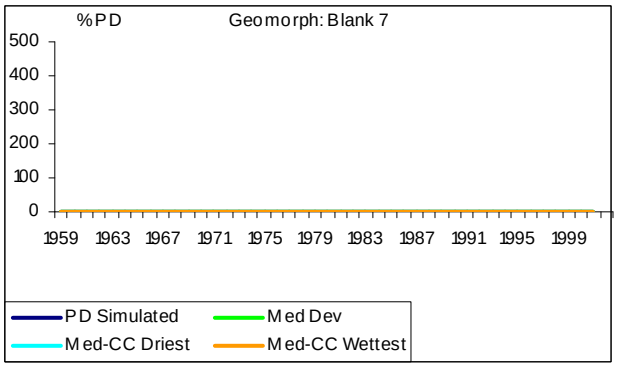
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

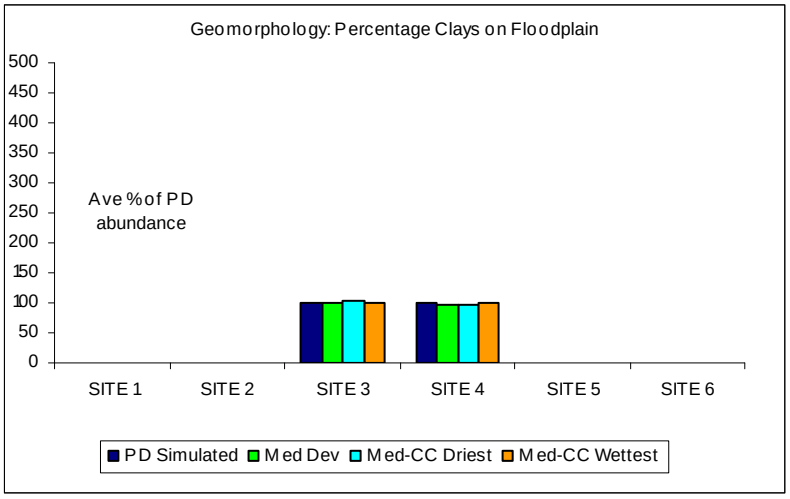


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Silt and clay tend to get lost due to downward mixing by soil organisms, trampling by livestock, and removal by wind. However, these fine particles are replenished by flooding.



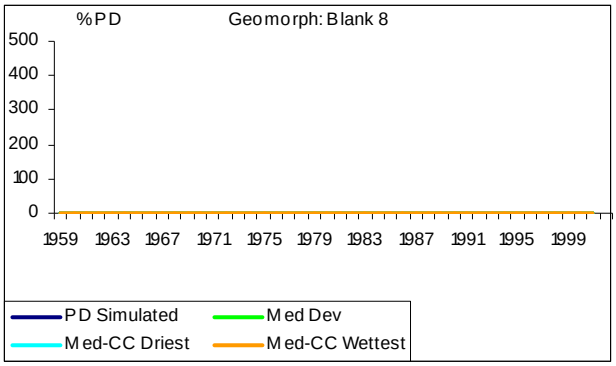
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

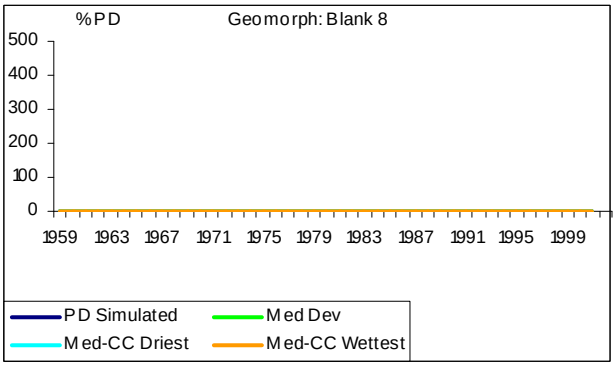
4.1.8 Extent of inundated floodplain

(Extent of the floodplain flooded each wet season)- Reduced volume of flow in the flood season will result in less overbank flooding. This results in smaller areas of the floodplain being inundated.

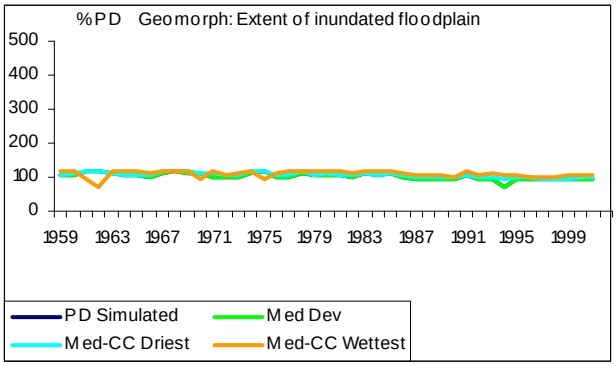
Site 1: Cubango River @ Capico



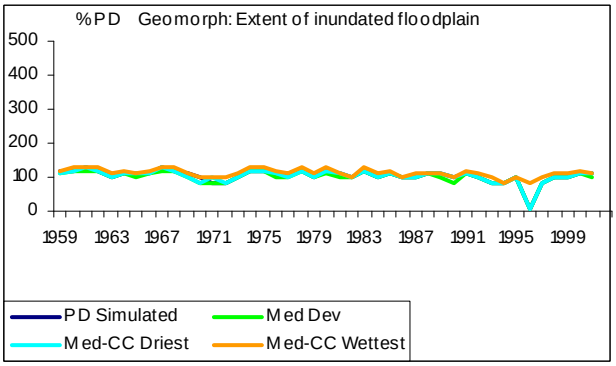
Site 2: Cubango River @ Mucundi



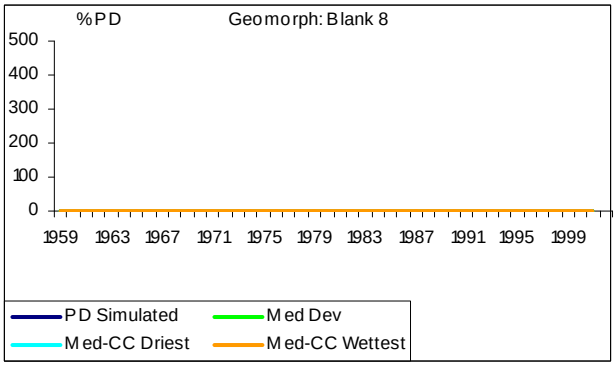
Site 3: Cuito River @ Cuito Cuanavale



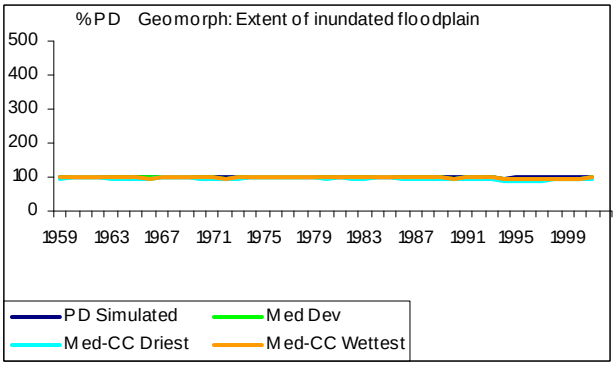
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

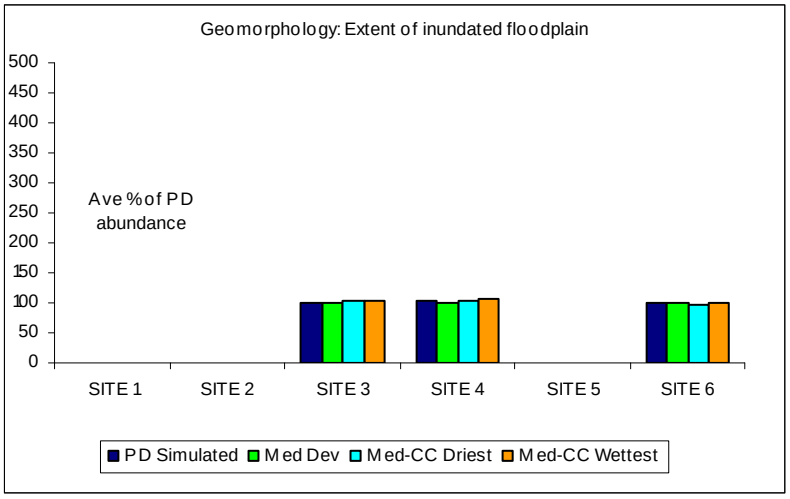


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Reduced volume of flow in the flood season will result in less overbank flooding. This results in smaller areas of the floodplain being inundated.



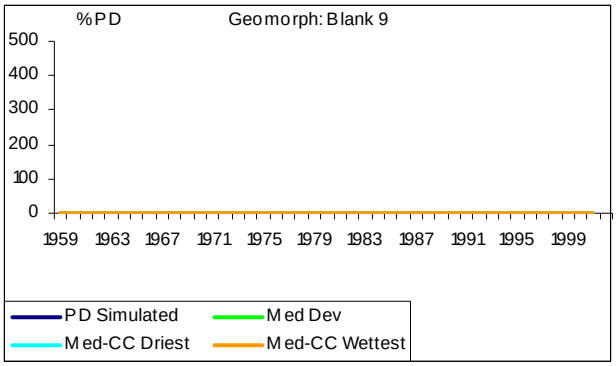
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

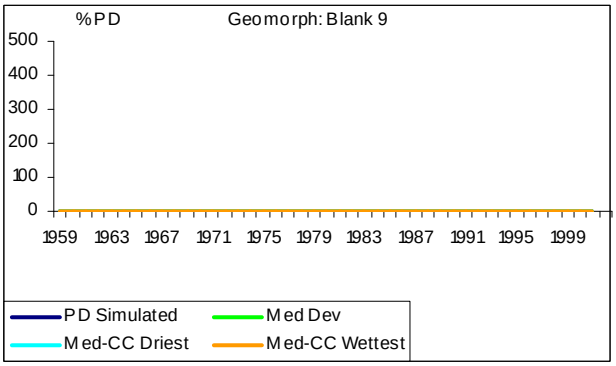
4.1.9 Inundated pools and pans

(Extent of Inundated Pools/Pans on Floodplain at the end of the Dry Season)- Pools that remain on the floodplain at the end of the dry season are assumed to be fed by groundwater movement from the river channel.

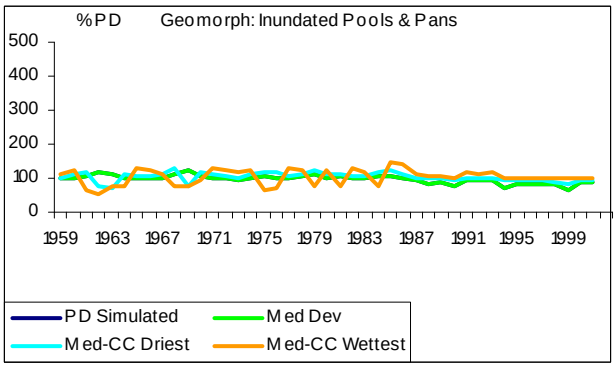
Site 1: Cubango River @ Capico



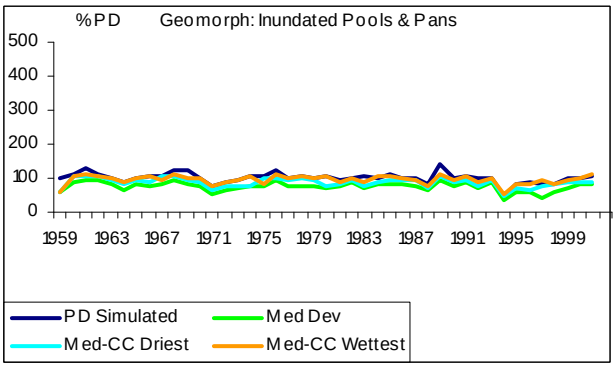
Site 2: Cubango River @ Mucundi



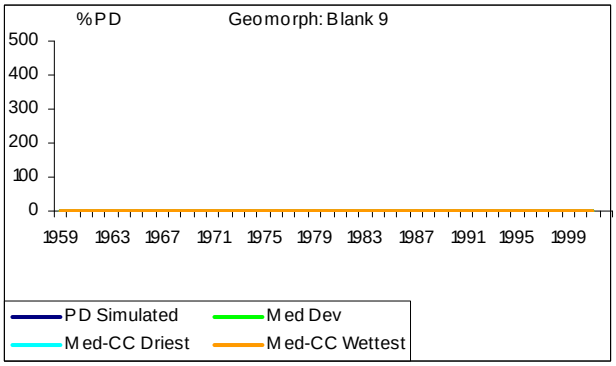
Site 3: Cuito River @ Cuito Cuanavale



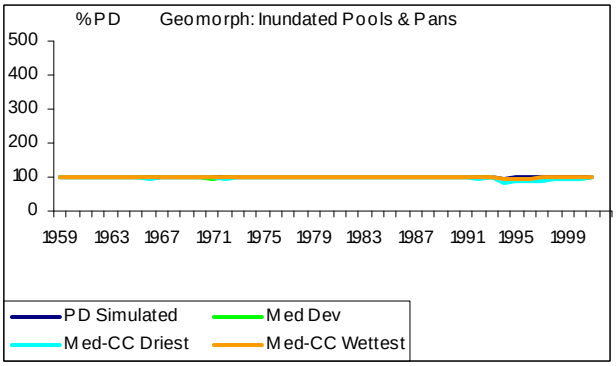
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

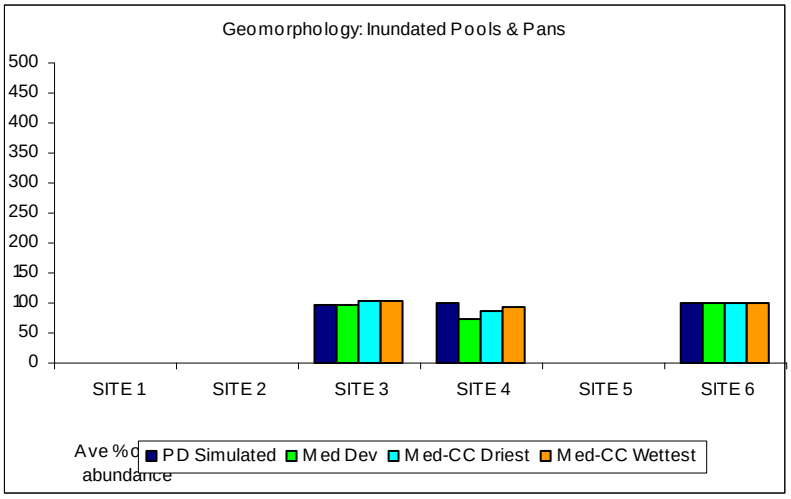


Site 6: Okavango River @ Pan Handle



Summary change per scenario

As the river level drops, so the water table in the floodplain will also drop. If the bed of a pool no longer intersects the water table, the pool will dry out. (Seepage into the pool from the non-saturated zone may also contribute to pool water.) Athough high flows paly a role by replenishing groundwater in floodplains, we assume that perennial pools at the end of the dry season are maintained by groundwater.



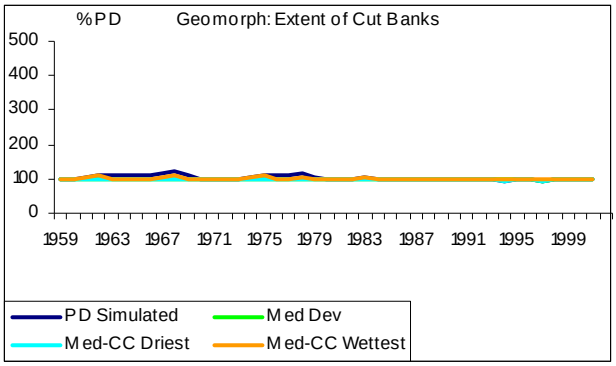
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

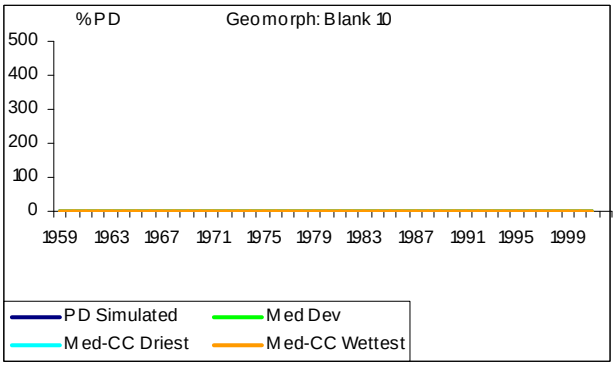
4.1.10 Extent of cut banks

(Extent of cut banks Along the Active Channel)- Cut banks are a function mainly of high flow periods, but they are also affected when river flow drops rapidly - in that case bank collapse tends to occur.

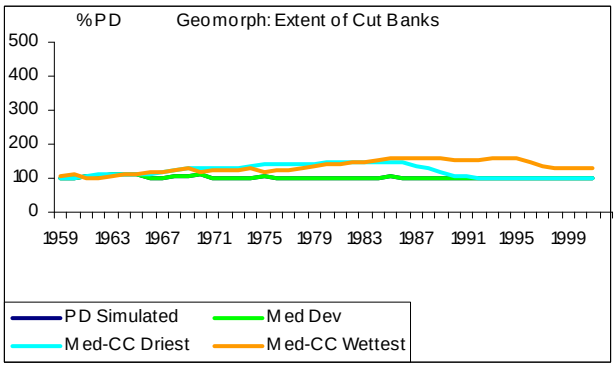
Site 1: Cubango River @ Capico



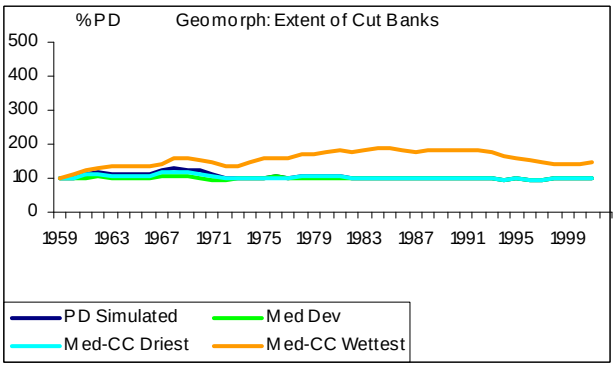
Site 2: Cubango River @ Mucundi



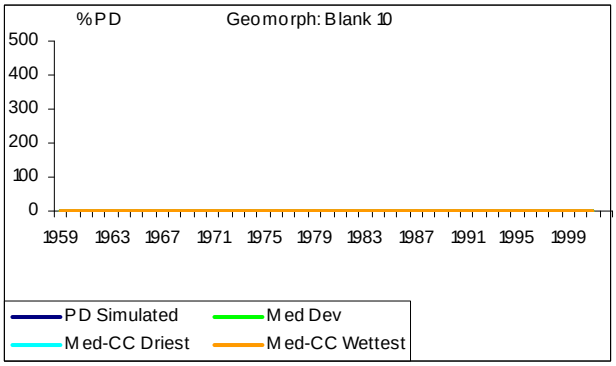
Site 3: Cuito River @ Cuito Cuanavale



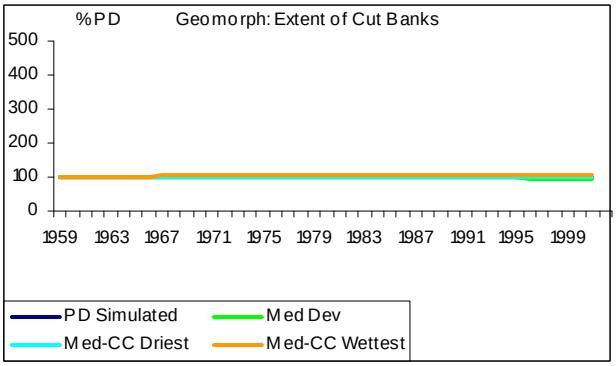
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

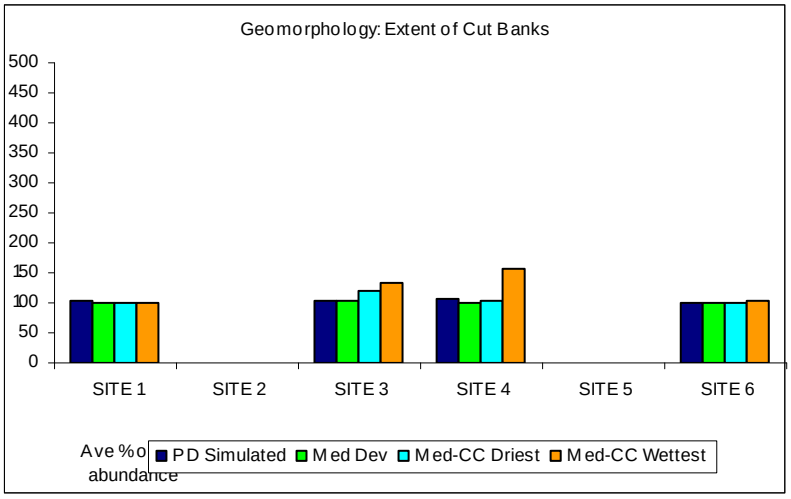


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Higher flow velocities during flooding will erode the banks. When the water level drops rapidly, then hydrostatic pressure of water in the sandy bank material tends to result in bank collapse.

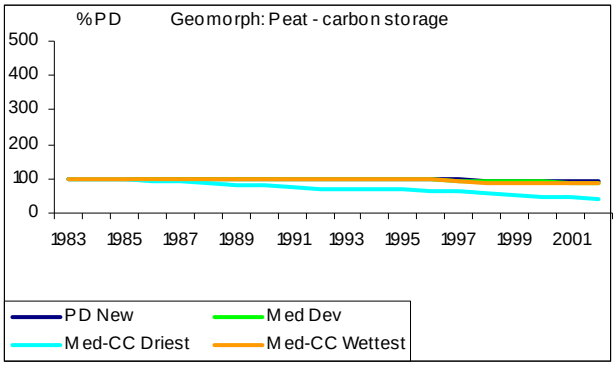


References

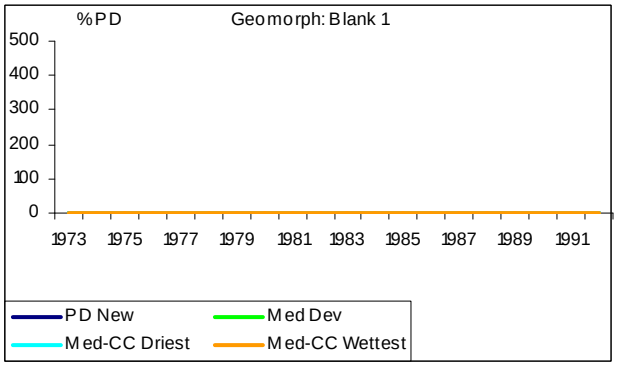
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.1.11 Peat - carbon storage

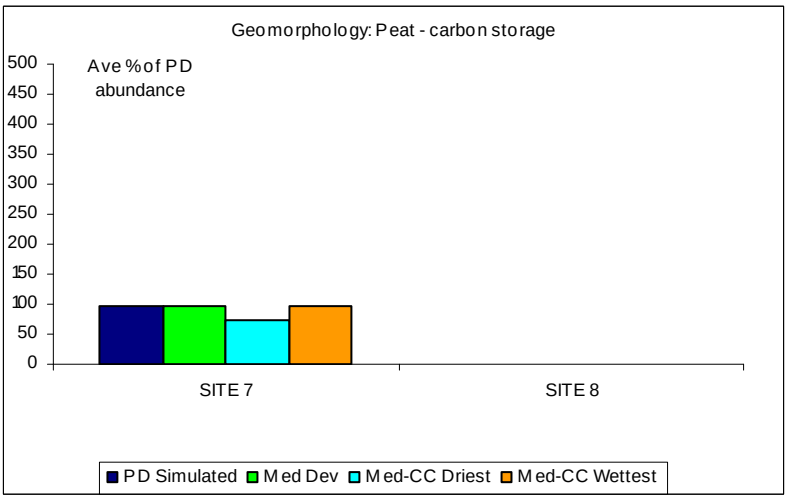
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.2. Water Quality

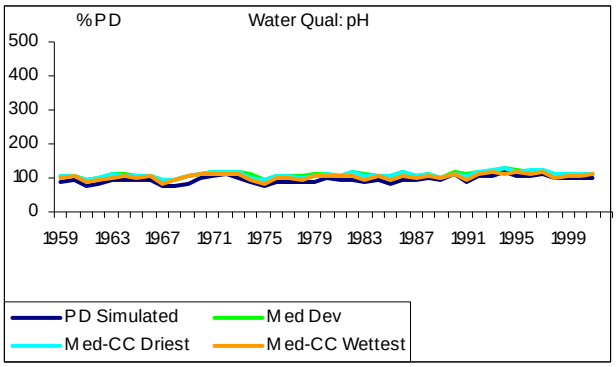
This section provides the time-series for water quality indicators under the flow regime resulting from the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- pH
- Conductivity
- Temperature
- Turbidity
- Dissolved oxygen
- Total nitrogen
- Total phosphorus
- Chlorophyll a.

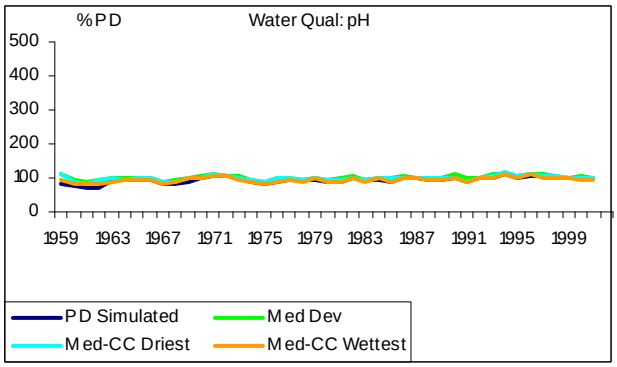
4.2.1 pH

(In channel)- Unitless

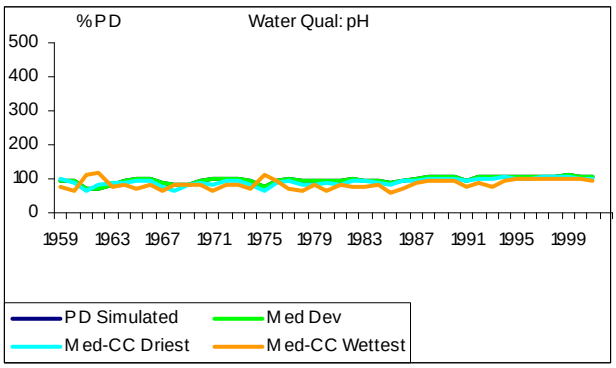
Site 1: Cubango River @ Capico



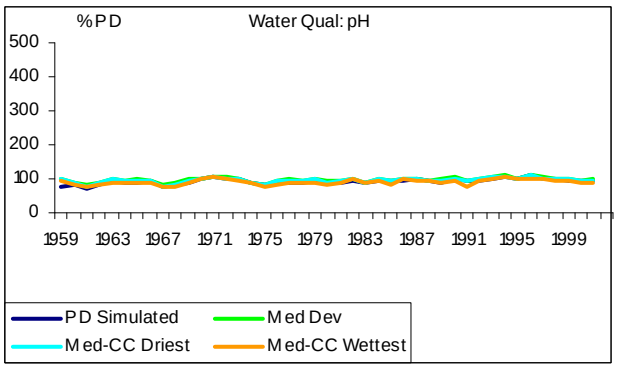
Site 2: Cubango River @ Mucundi



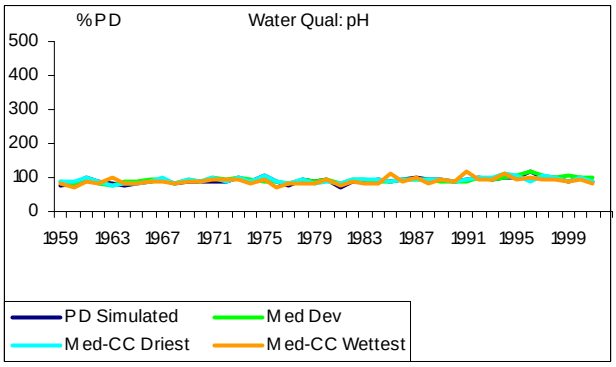
Site 3: Cuito River @ Cuito Cuanavale



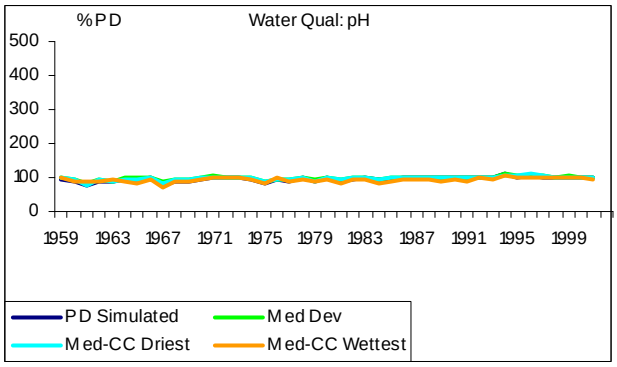
Site 4: Okavango River @ Rundu



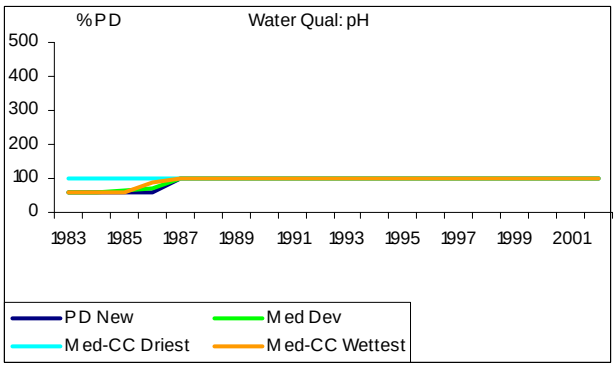
Site 5: Okavango River @ Popa Falls



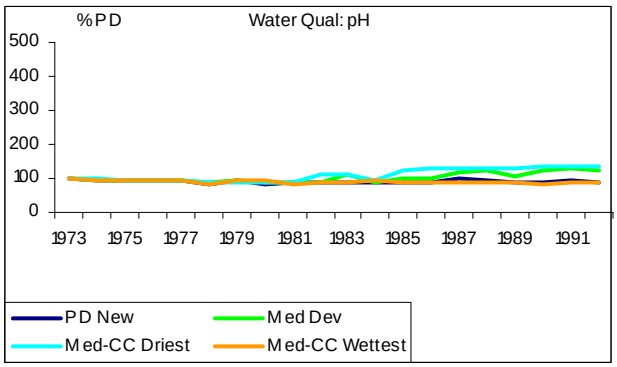
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

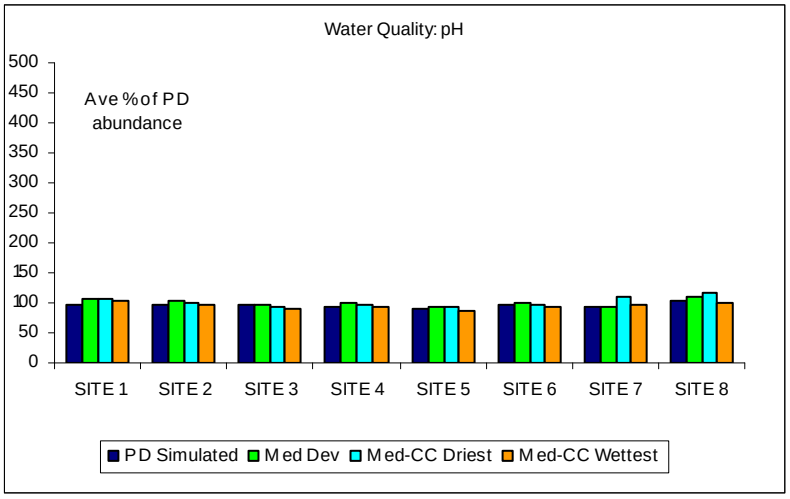


Site 8: Boteti River



Summary change per scenario

Generally increasing with decreasing flow. In the simulated Present Day, values range between 34% and 268% of the PD median, increasing in drier years of lower flow.



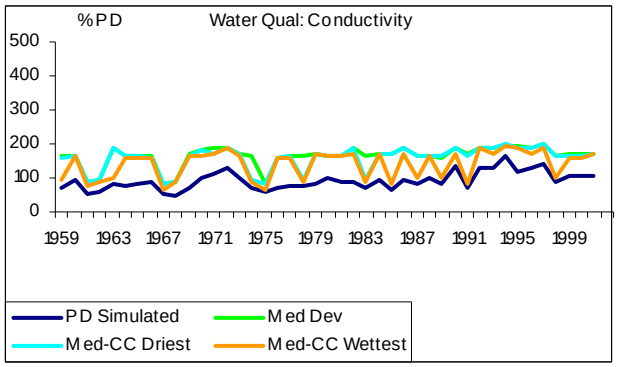
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

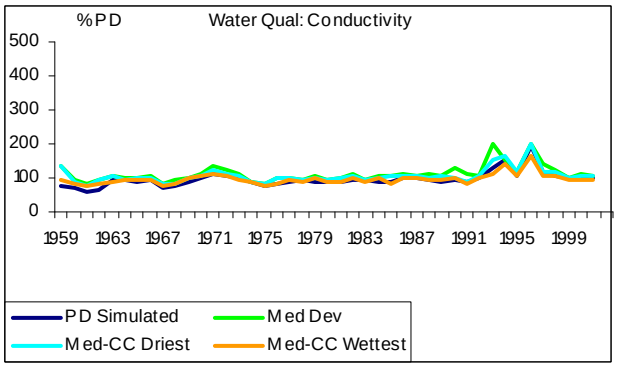
4.2.2 Conductivity

(In channel)- us/cm

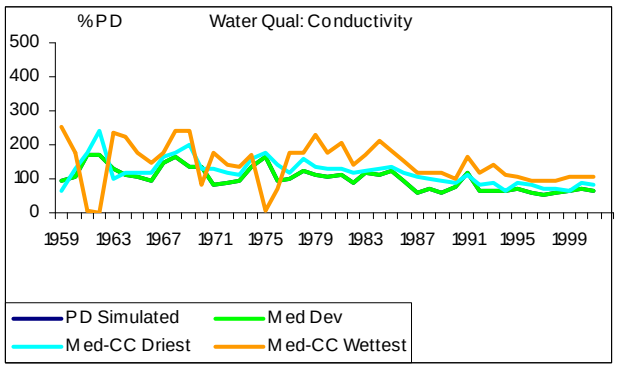
Site 1: Cubango River @ Capico



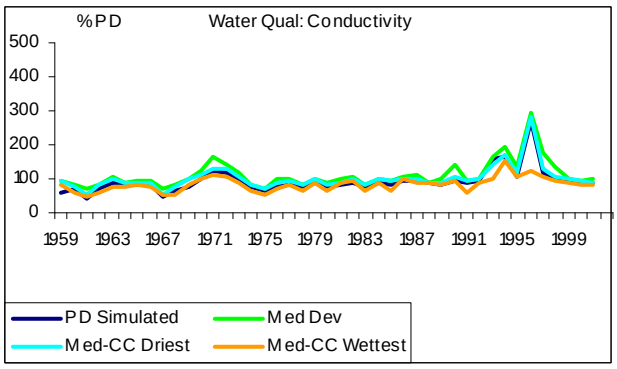
Site 2: Cubango River @ Mucundi



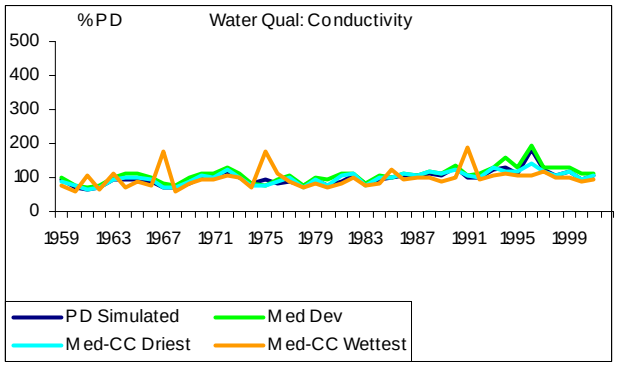
Site 3: Cuito River @ Cuito Cuanavale



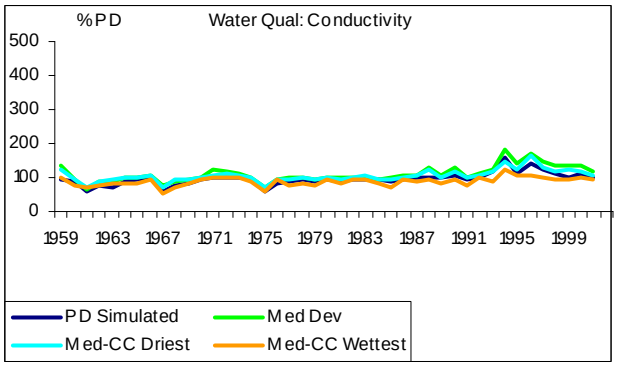
Site 4: Okavango River @ Rundu



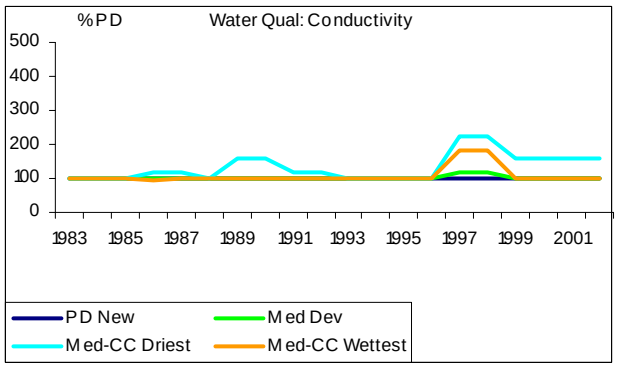
Site 5: Okavango River @ Popa Falls



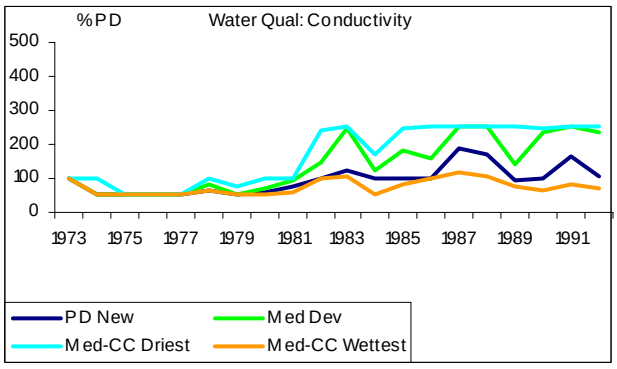
Site 6: Okavango River @ Pan Handle



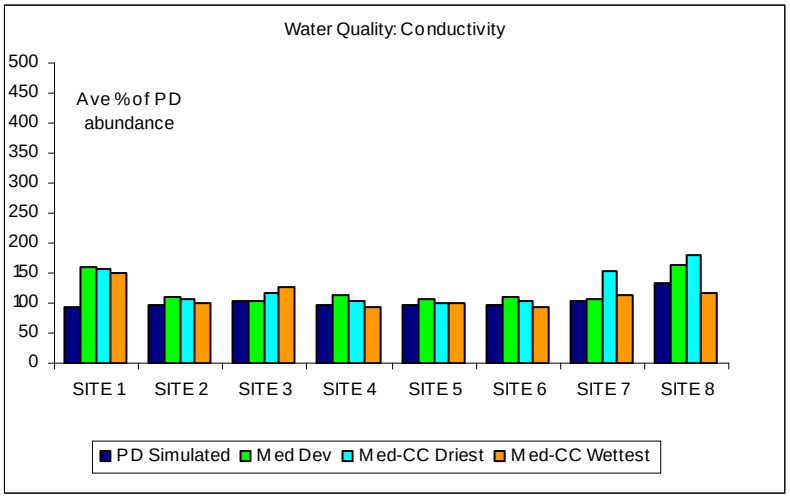
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Values decrease with increasing flow.

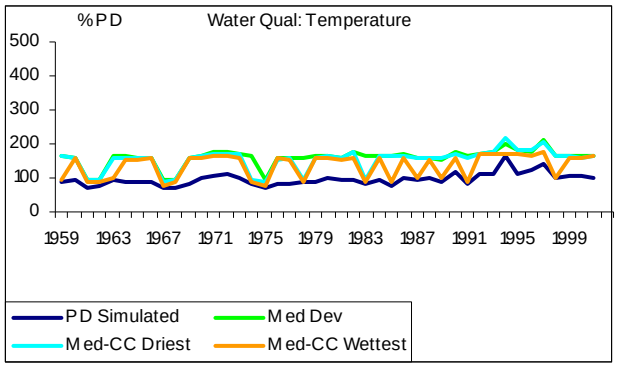


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

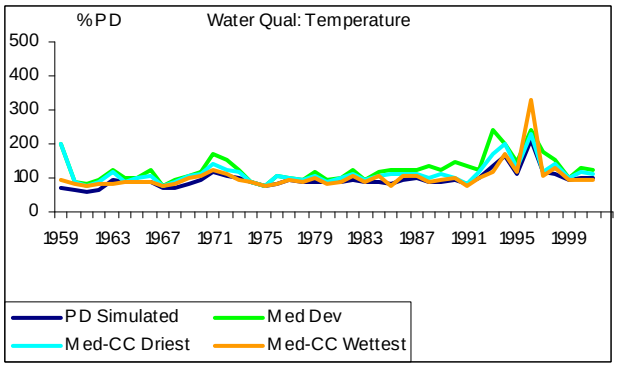
4.2.3 Temperature

(In channel)- diel range

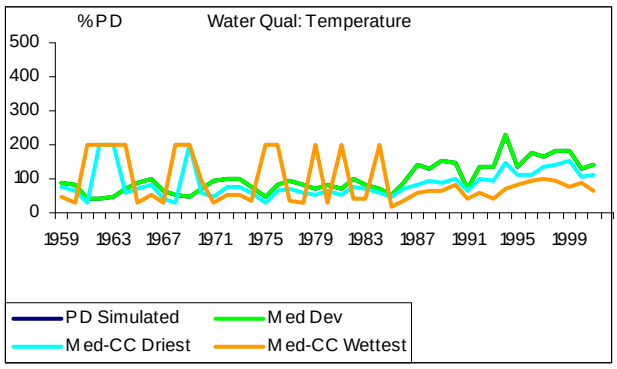
Site 1: Cubango River @ Capico



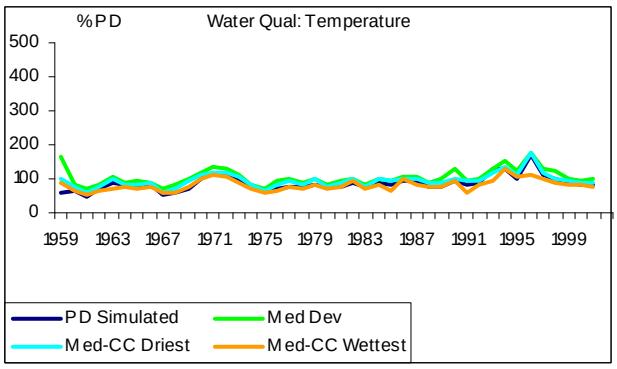
Site 2: Cubango River @ Mucundi



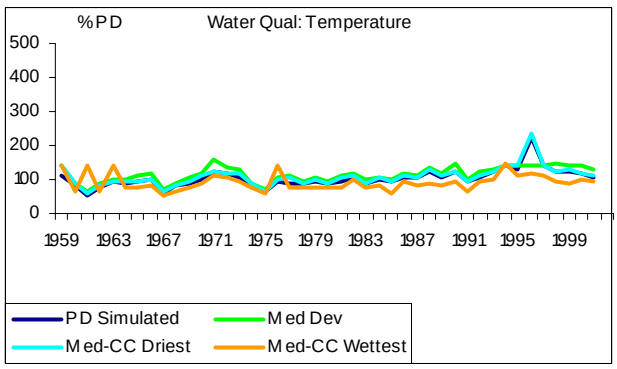
Site 3: Cuito River @ Cuito Cuanavale



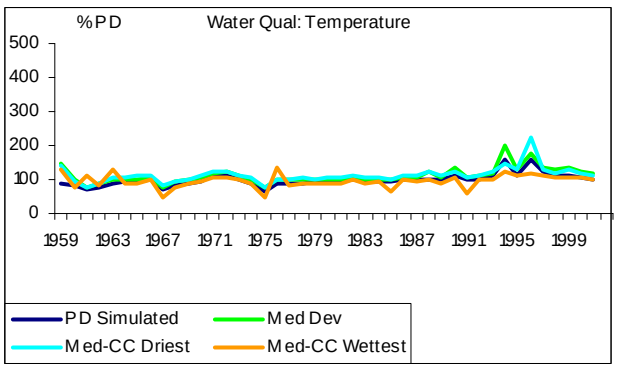
Site 4: Okavango River @ Rundu



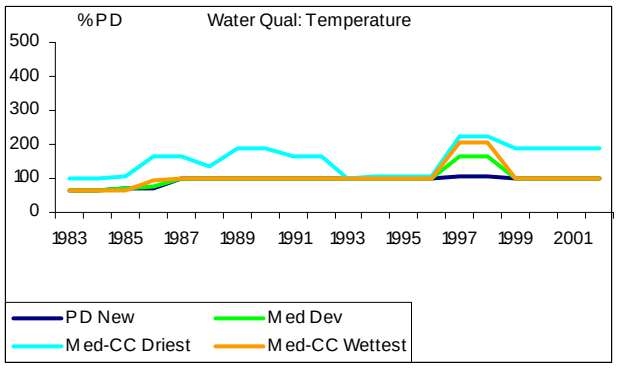
Site 5: Okavango River @ Popa Falls



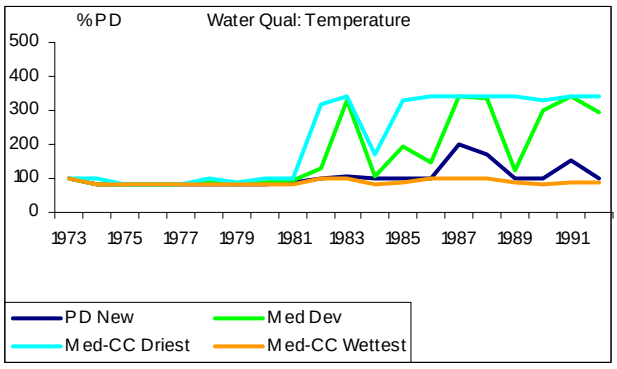
Site 6: Okavango River @ Pan Handle



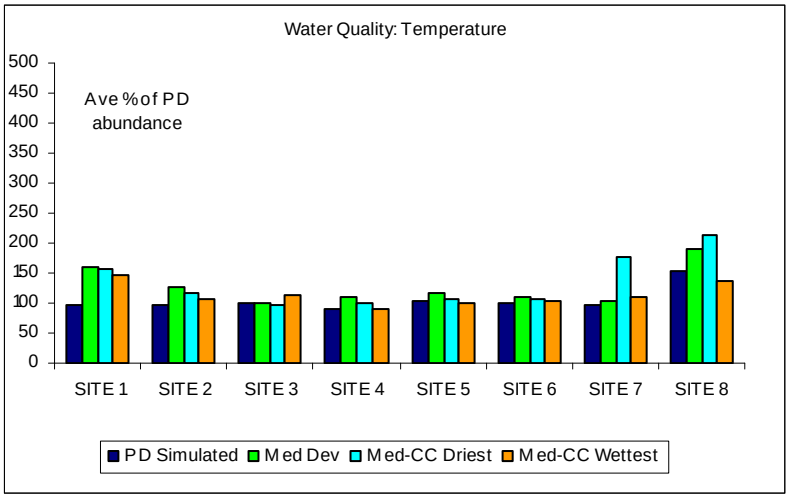
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Generally the Diel Temperature Range increases with decreasing flow.

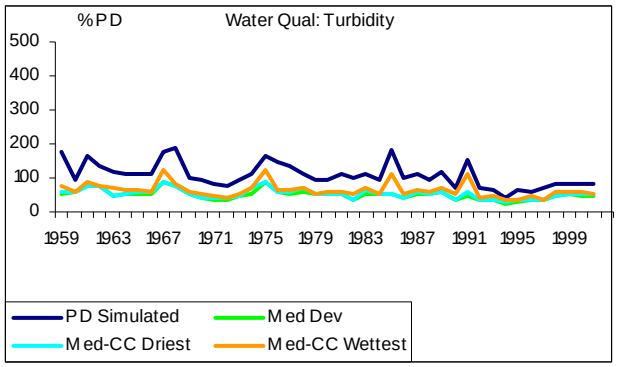


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

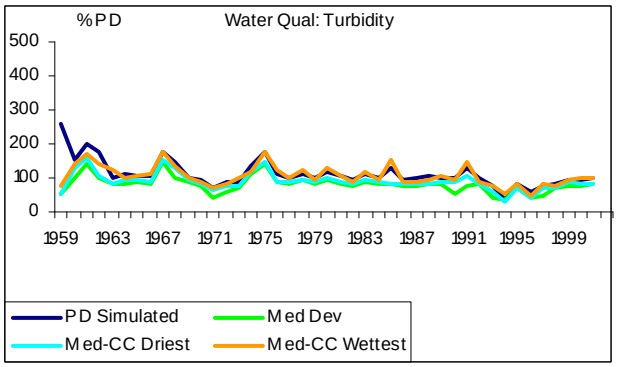
4.2.4 Turbidity

(In channel)- mg/l

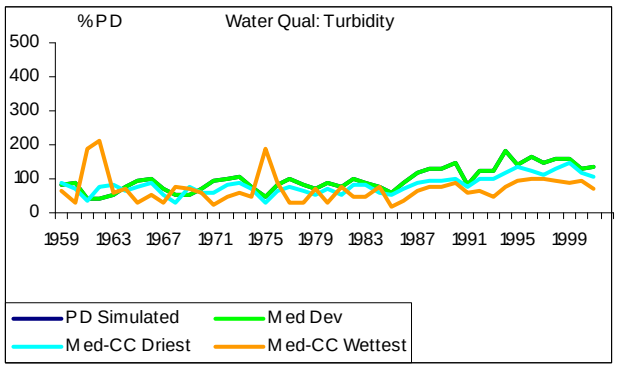
Site 1: Cubango River @ Capico



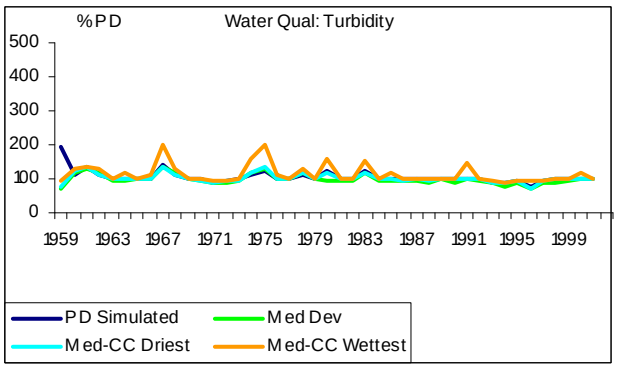
Site 2: Cubango River @ Mucundi



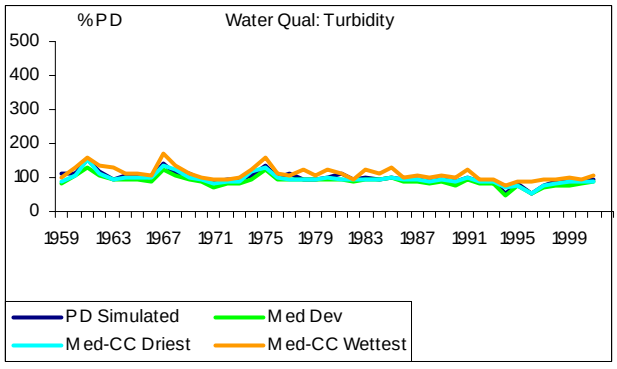
Site 3: Cuito River @ Cuito Cuanavale



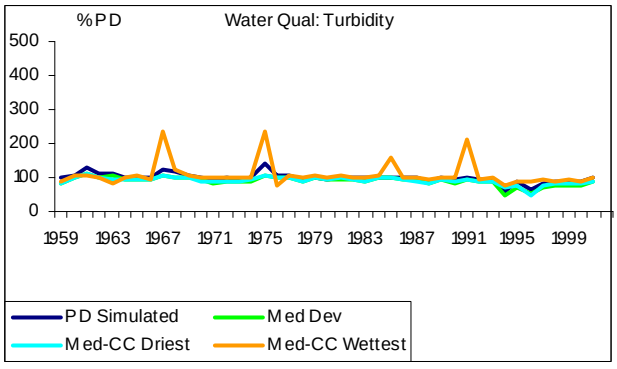
Site 4: Okavango River @ Rundu



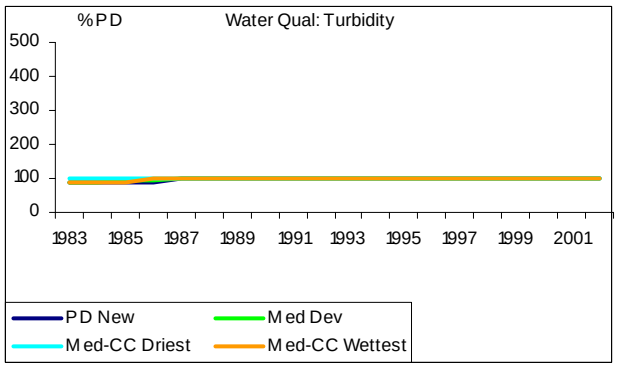
Site 5: Okavango River @ Popa Falls



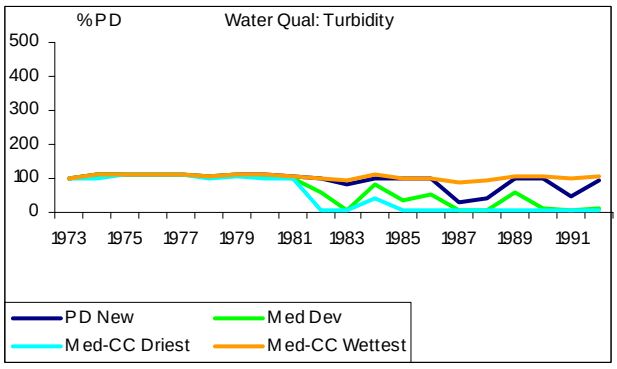
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

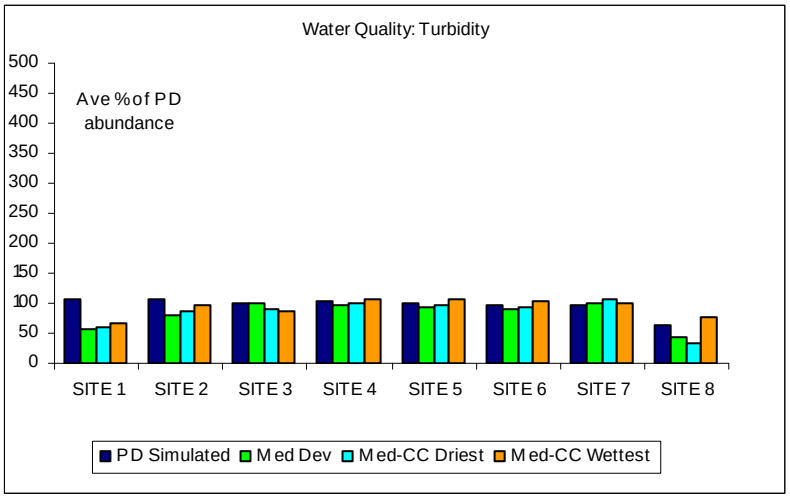


Site 8: Boteti River



Summary change per scenario

In general turbidity increases with increasing flows. The exception to this is Site 7 where turbidity decreases with increasing depth. In the case of the Boteti (Site 8), the inundated (and sometimes flowing) channels tend to have higher turbidity than the isolated pools. However when the Boteti dries up, there is 'no turbidity'.



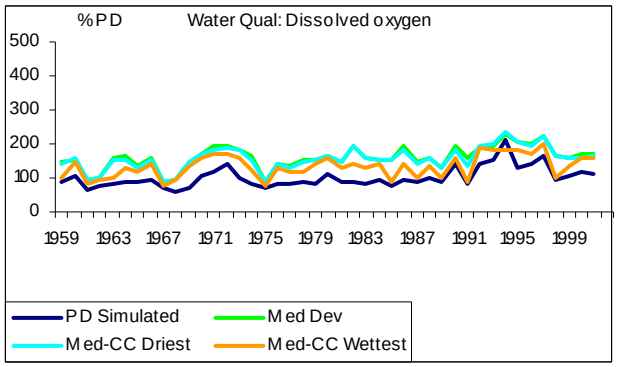
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

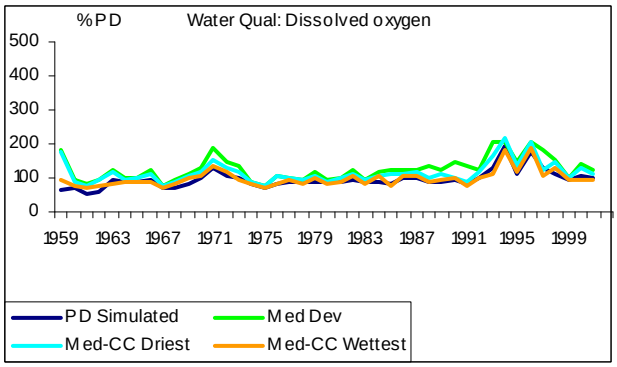
4.2.5 Dissolved oxygen

(In channel)- NTU

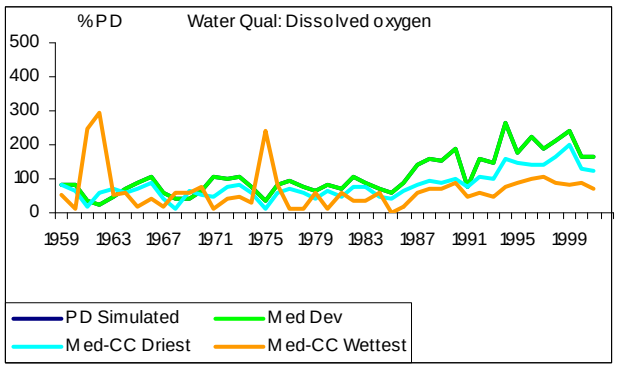
Site 1: Cubango River @ Capico



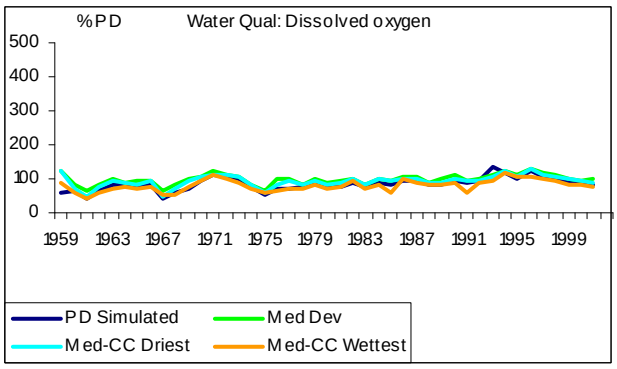
Site 2: Cubango River @ Mucundi



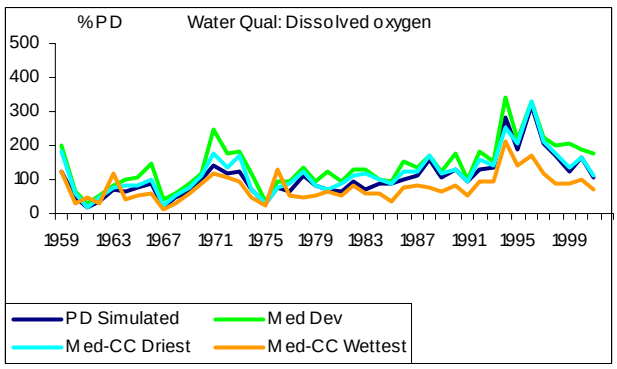
Site 3: Cuito River @ Cuito Cuanavale



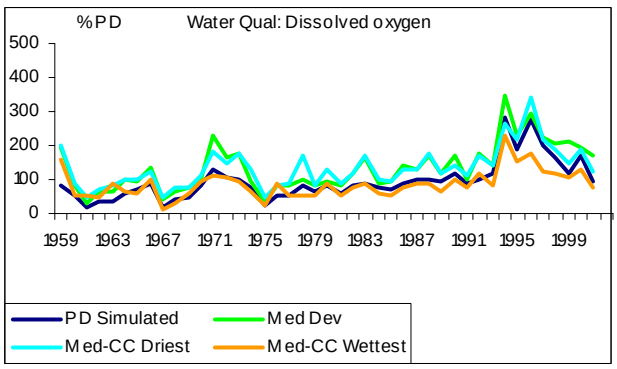
Site 4: Okavango River @ Rundu



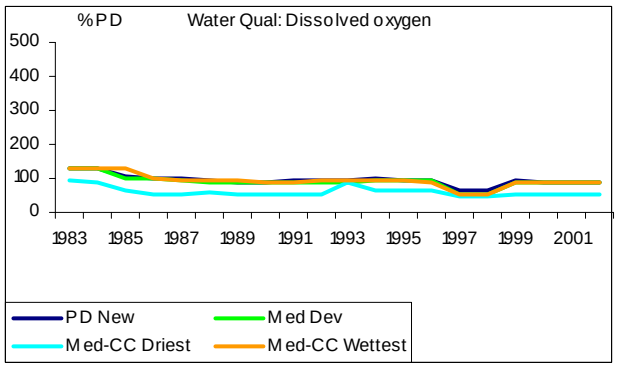
Site 5: Okavango River @ Popa Falls



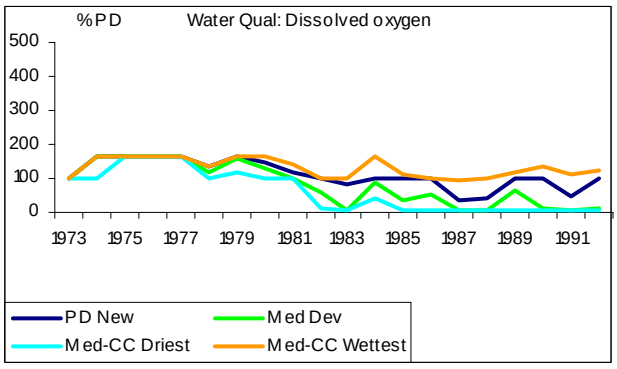
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

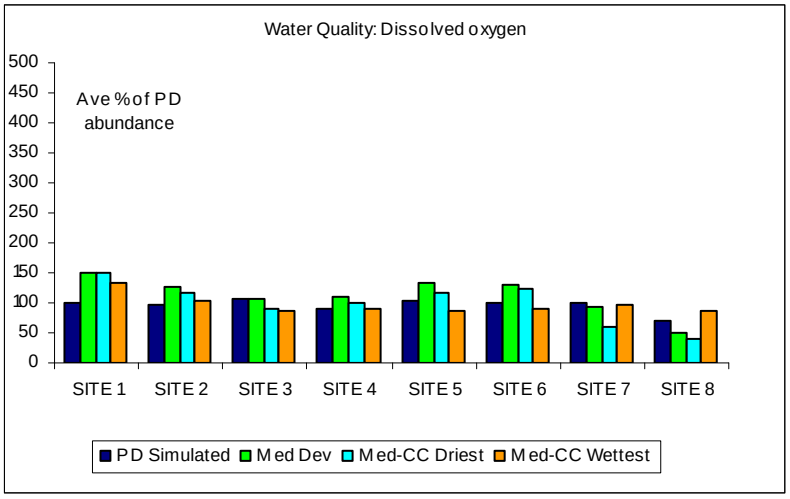


Site 8: Boteti River



Summary change per scenario

Decrease in flow results in increase in Dissolved Oxygen at sites 1 - 6. At sites 7 & 8, the concentrations decrease with decrease in flow



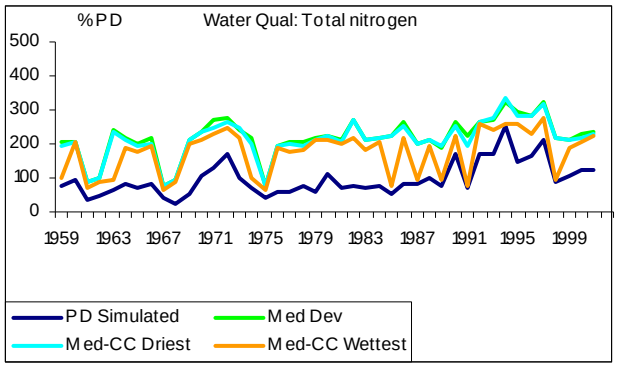
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

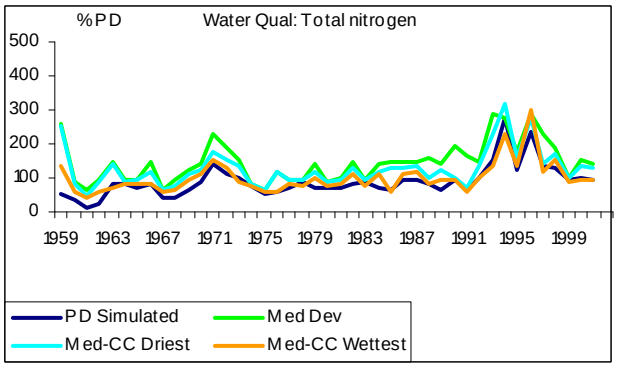
4.2.6 Total nitrogen

(In channel)- mg/l

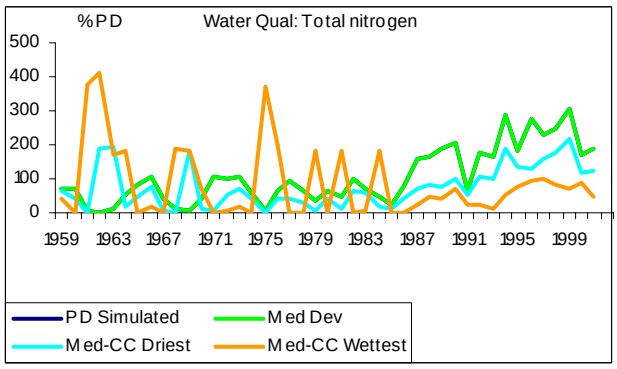
Site 1: Cubango River @ Capico



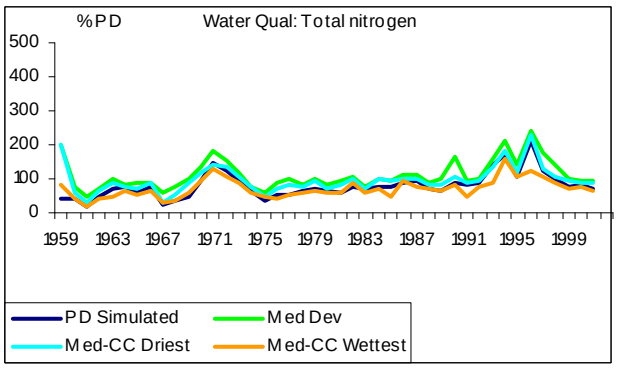
Site 2: Cubango River @ Mucundi



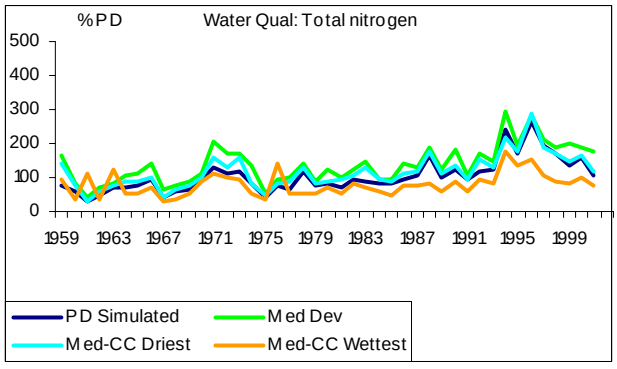
Site 3: Cuito River @ Cuito Cuanavale



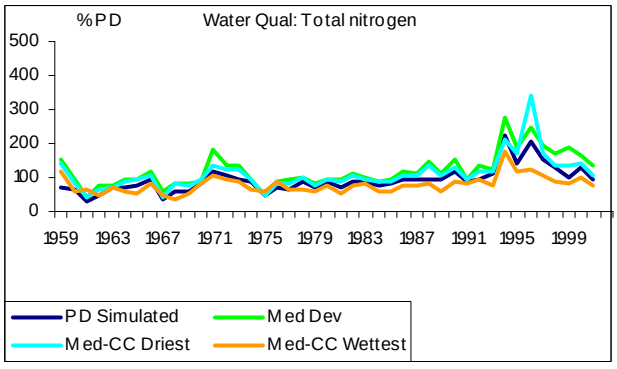
Site 4: Okavango River @ Rundu



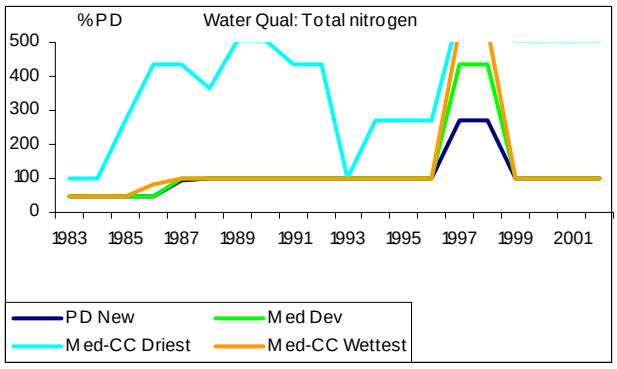
Site 5: Okavango River @ Popa Falls



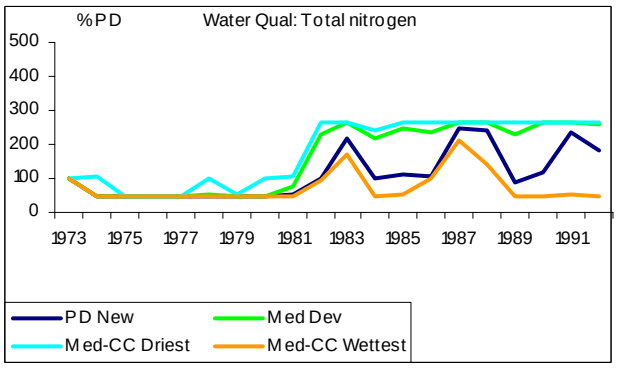
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

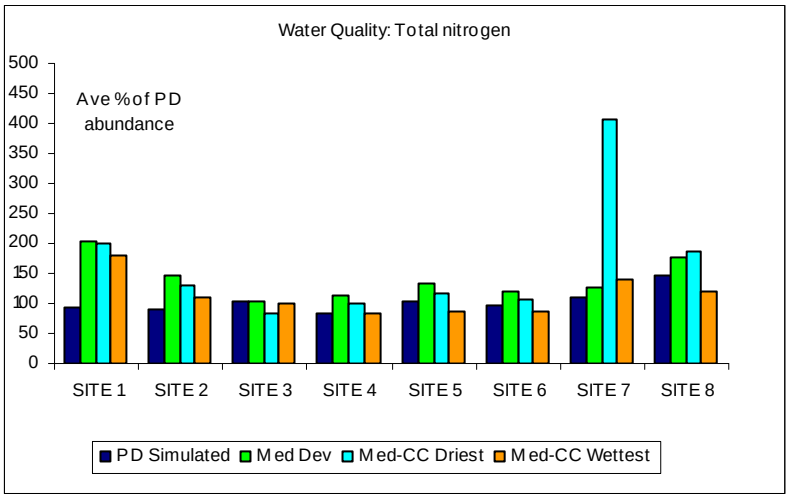


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of nitrogen.



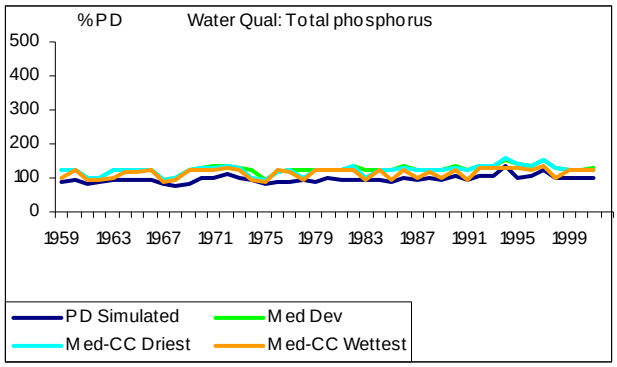
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

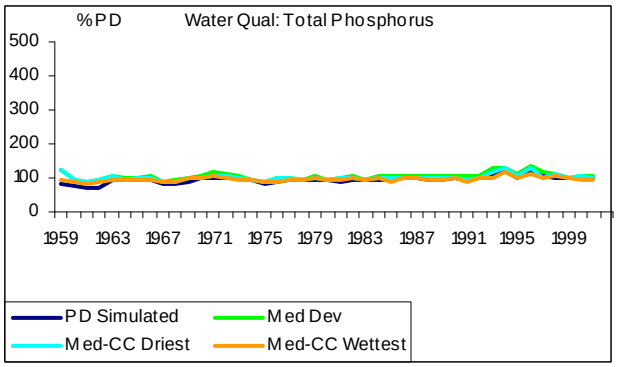
4.2.7 Total phosphorus

(In channel)- mg/l

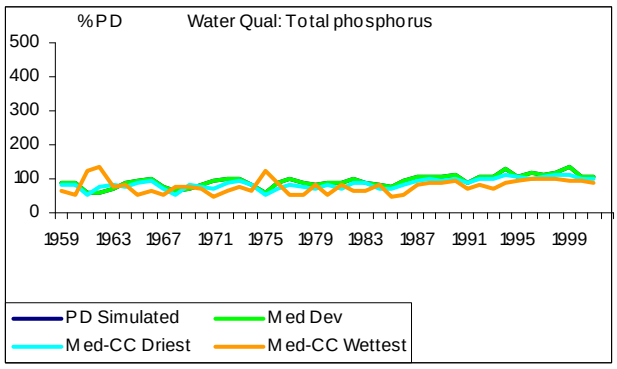
Site 1: Cubango River @ Capico



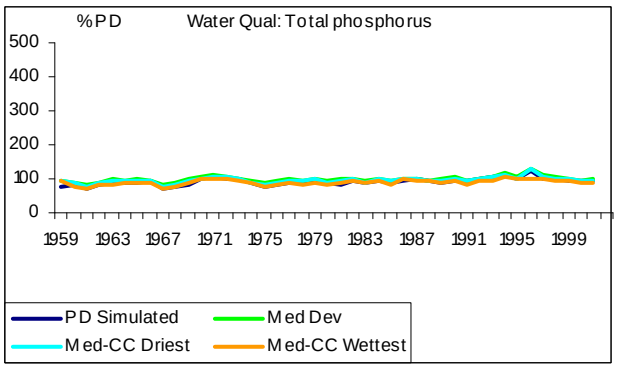
Site 2: Cubango River @ Mucundi



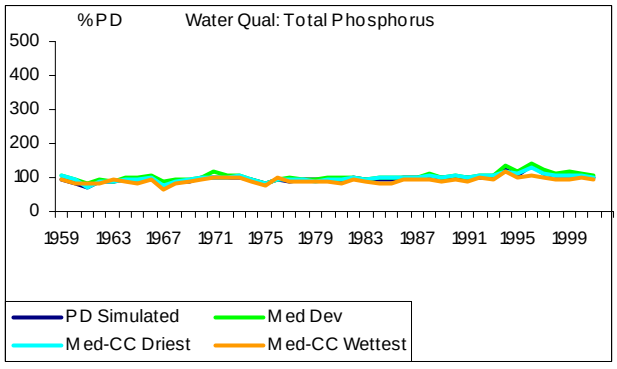
Site 3: Cuito River @ Cuito Cuanavale



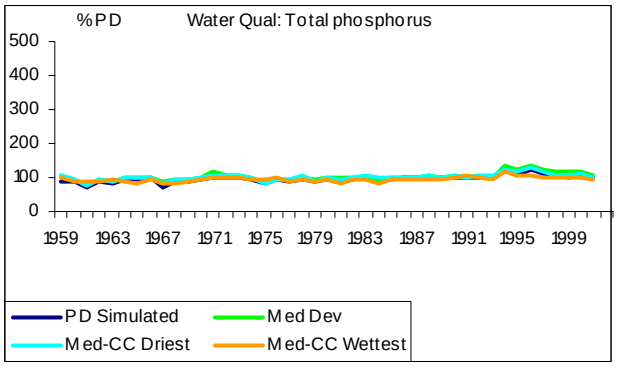
Site 4: Okavango River @ Rundu



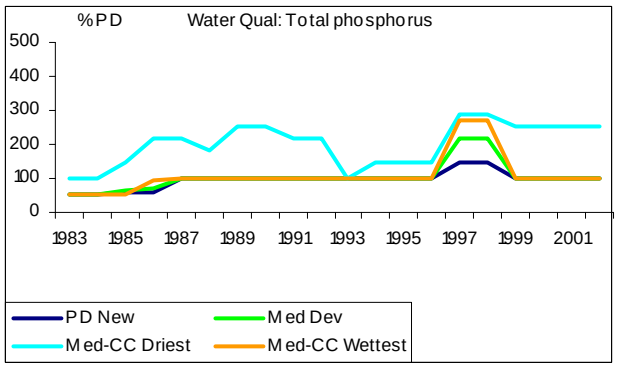
Site 5: Okavango River @ Popa Falls



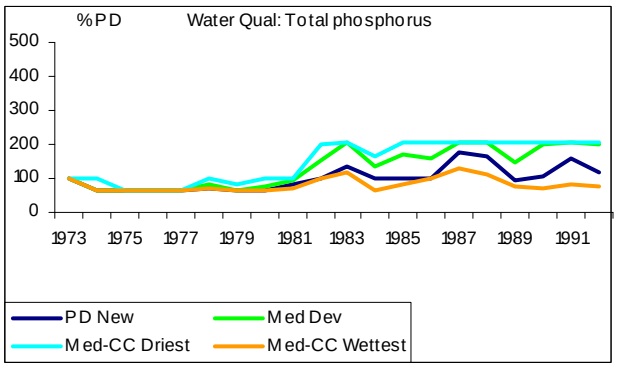
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

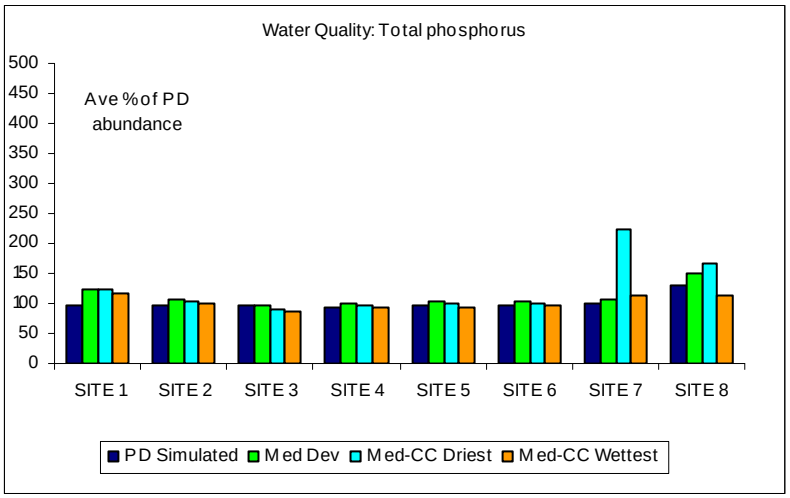


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites, but slightly lower than for total nitrogen. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of phosphorus.



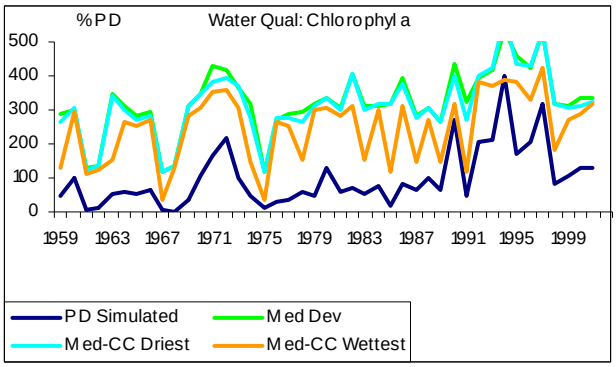
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

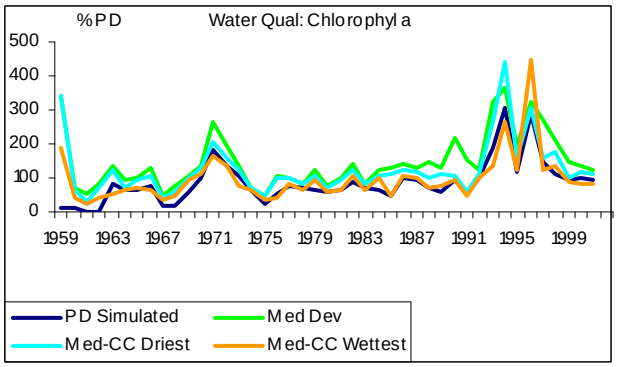
4.2.8 Chlorophyl a

(In channel)- ug/l

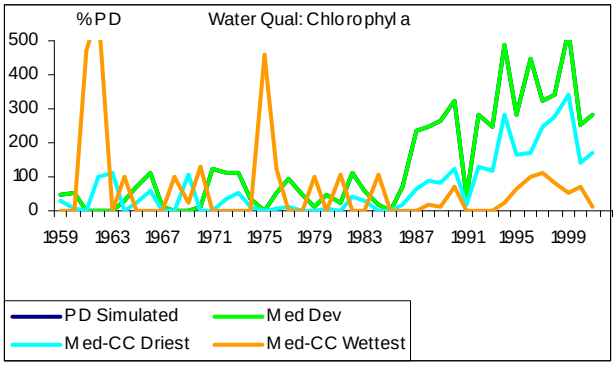
Site 1: Cubango River @ Capico



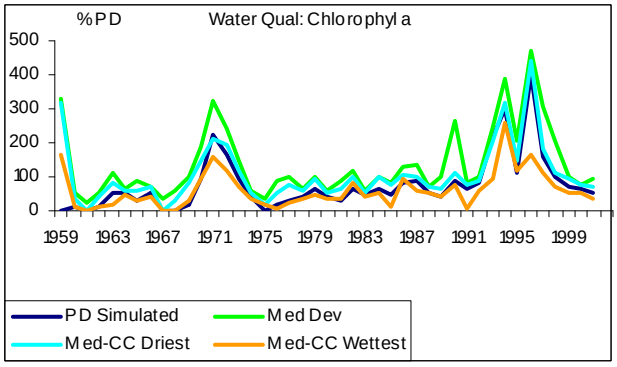
Site 2: Cubango River @ Mucundi



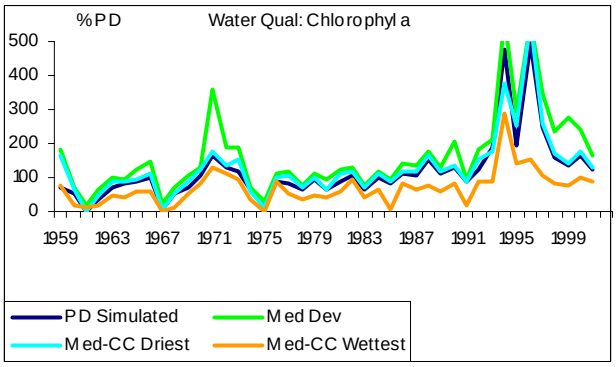
Site 3: Cuito River @ Cuito Cuanavale



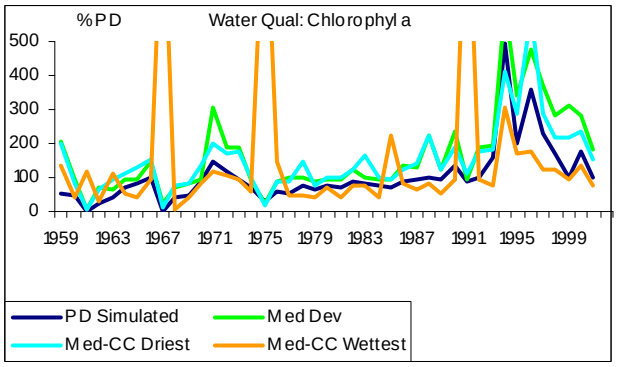
Site 4: Okavango River @ Rundu



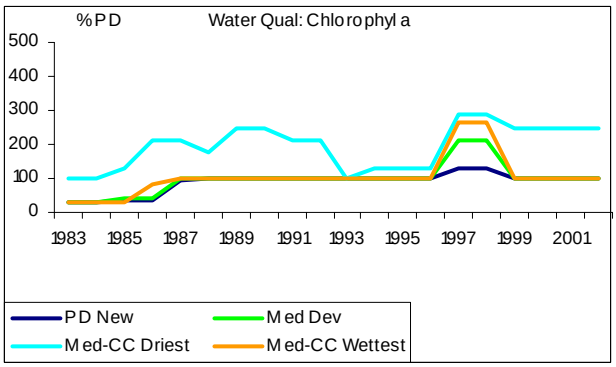
Site 5: Okavango River @ Popa Falls



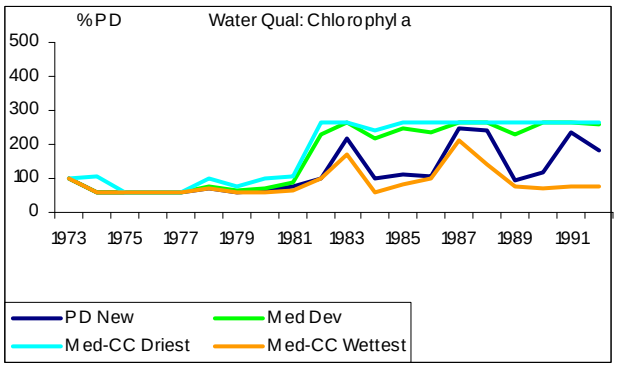
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

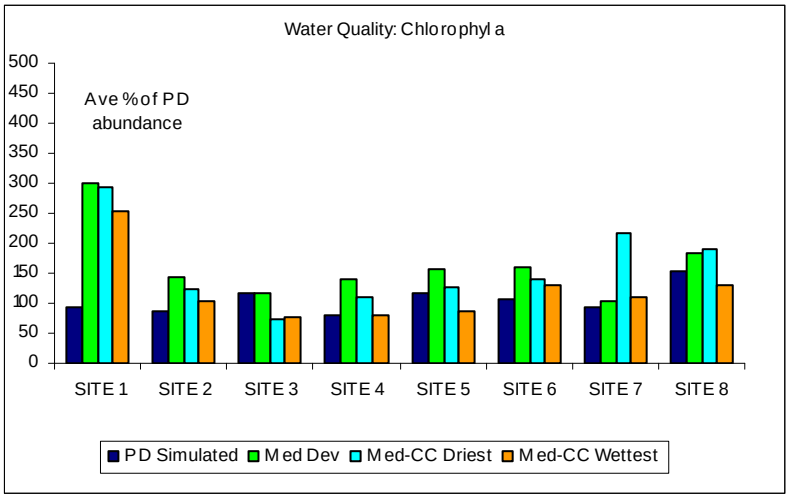


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites. The change in concentration is bigger than for total nitrates. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of chlorophyll a.



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3. Vegetation

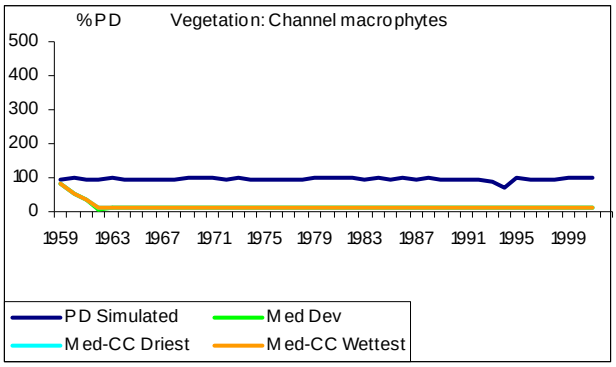
This section provides the time-series for vegetation indicators under the flow regime resulting from the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Channel macrophytes
- Lower wet bank (hippo grass, papyrus)
- Upper wet bank 1 (reeds)
- Upper wet bank 2 (trees, shrubs)
- River dry bank
- Floodplain dry bank
- Floodplain residual pools
- Lower floodplain
- Middle floodplain (grasses)
- Upper floodplain (trees,)
- Open waters
- Permanent swamps
- Lower floodplain
- Upper floodplain
- Occasionally flooded grassland
- *Sporobolus* islands
- Riparian woodland, trees
- Savanna and scrub
- Open water
- Riparian woodland, trees
- Channel-submerged vegetation
- Channel-marginal vegetation.

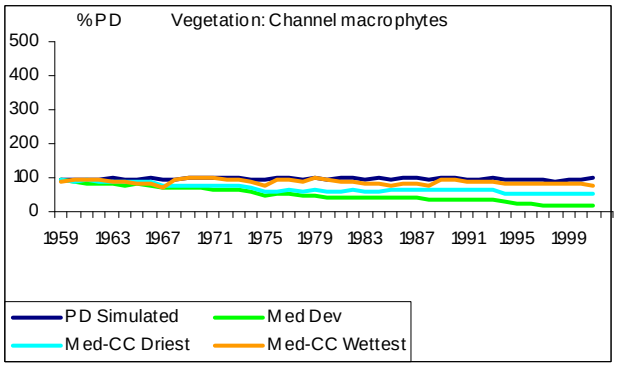
4.3.1 Channel macrophytes

(Edges of main channel or side channels. All or part of vegetation permanently submerged. Rooted or floating. Moving water.)- Potamogeton spp., Vallisneria, Lagarosiphon

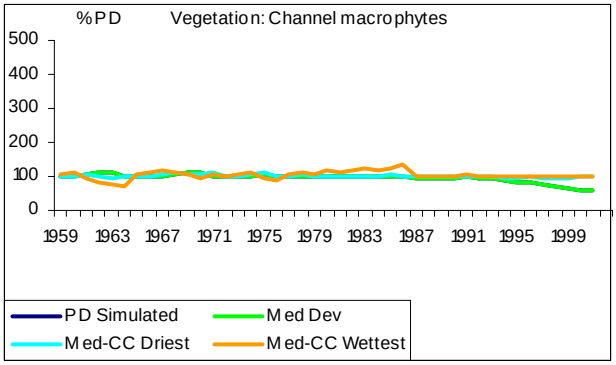
Site 1: Cubango River @ Capico



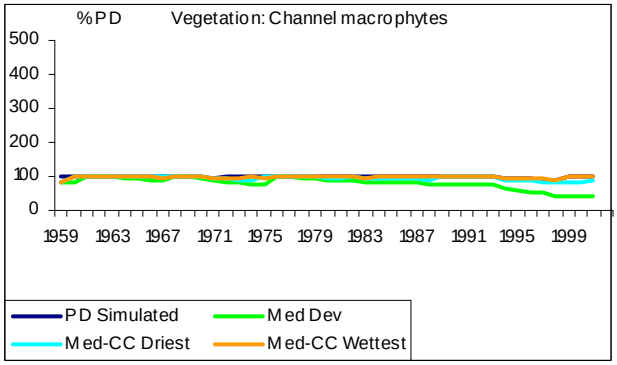
Site 2: Cubango River @ Mucundi



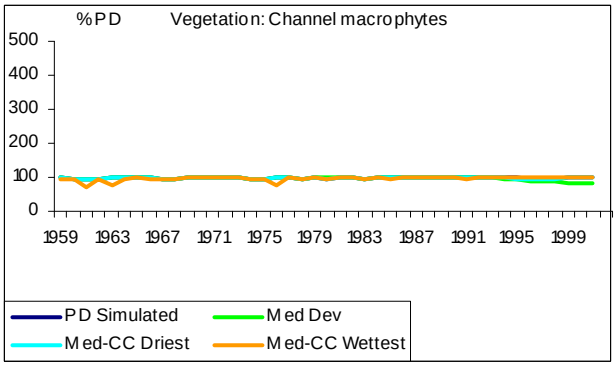
Site 3: Cuito River @ Cuito Cuanavale



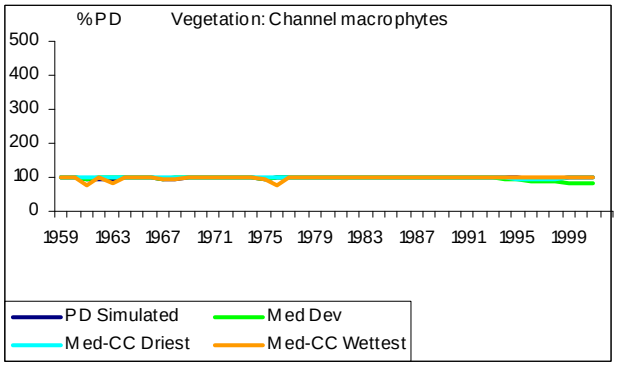
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

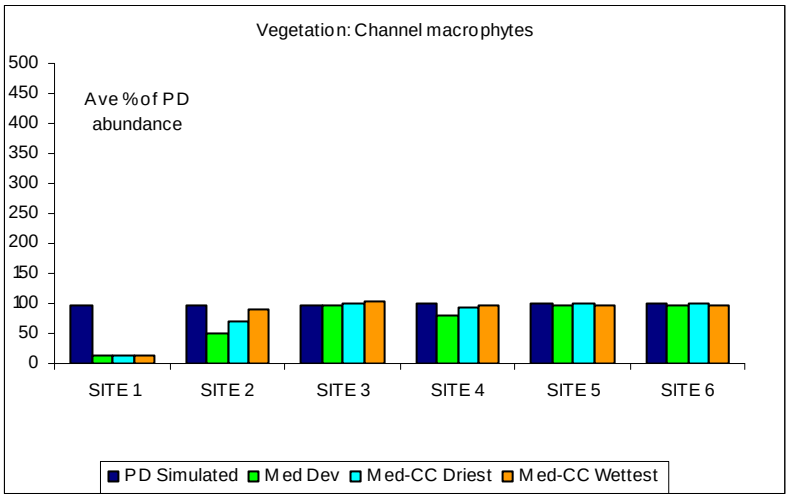


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Cover increases or decreases depending on water volume in dry season and could decline to zero if dry season channel dries. Sudden or very large floods could reduce cover. Onset and duration of either season of little impact.



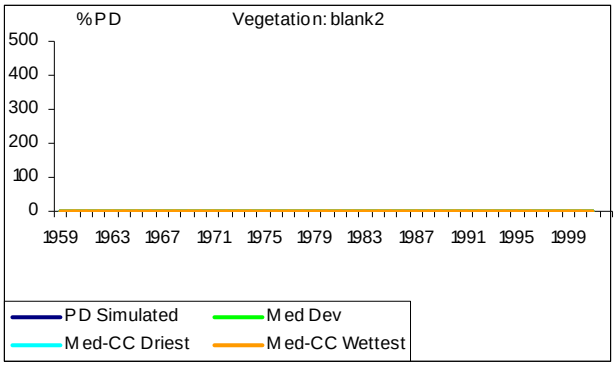
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

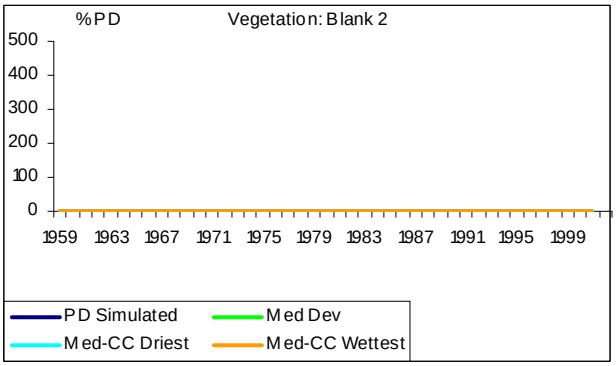
4.3.2 Lower wet bank (hippo,papyrus)

(Permanently wet inner margin in main channel. Floating plants with stems forming dense mat; leaves and flowers above water. Rooted in sand/peat. Moving water.)- Vossia cuspidata, Cyperus papyrus

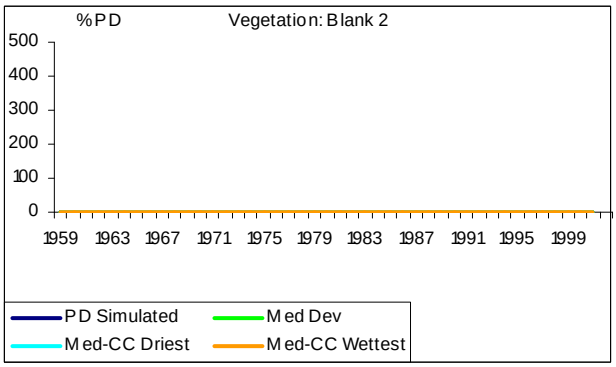
Site 1: Cubango River @ Capico



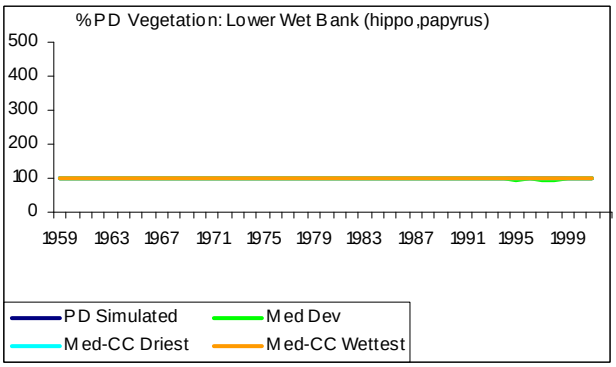
Site 2: Cubango River @ Mucundi



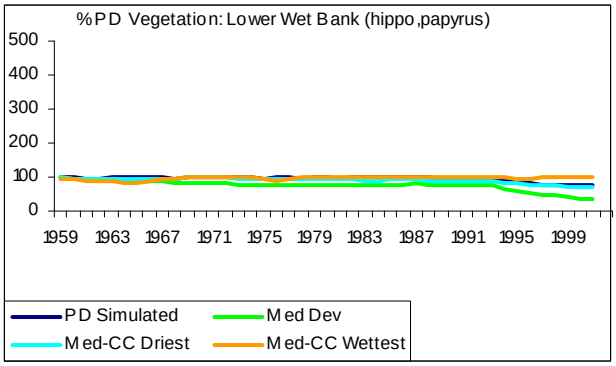
Site 3: Cuito River @ Cuito Cuanavale



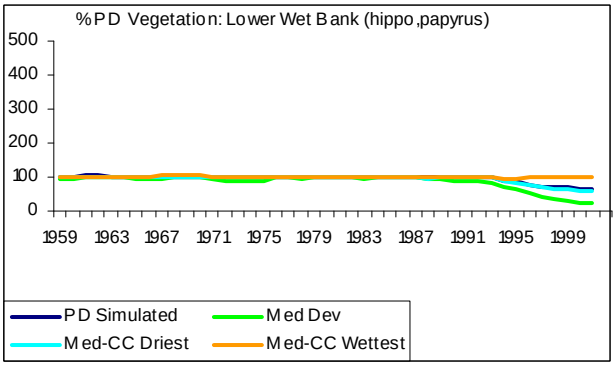
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

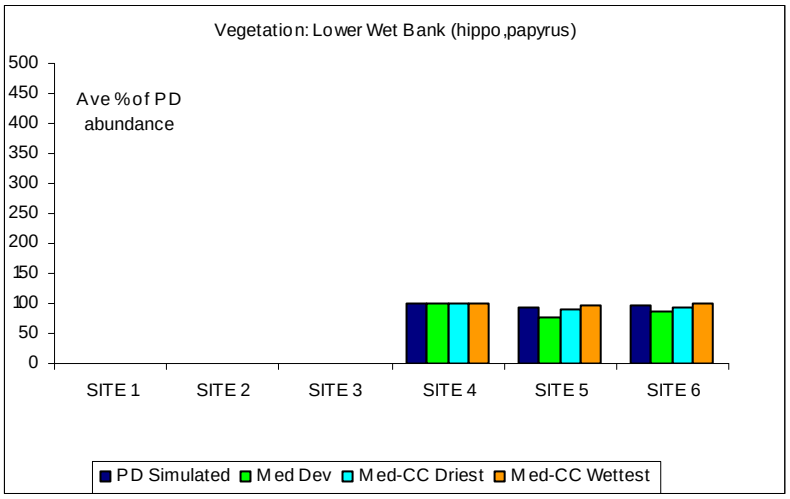


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Vossia will mimic the flow of the river as long as there is water to cover its roots. The leaves will float higher or lower as water level rises or falls. It can tolerate more dessication than can papyrus. Papyrus roots must also be



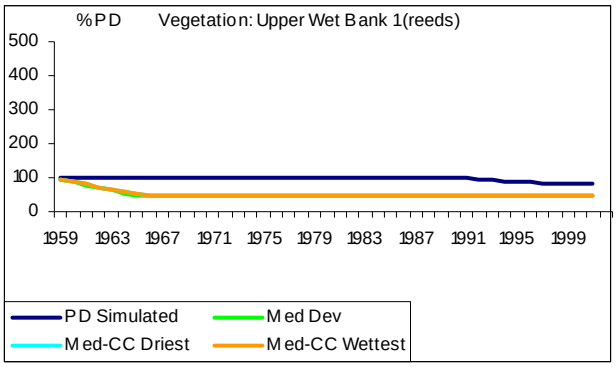
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

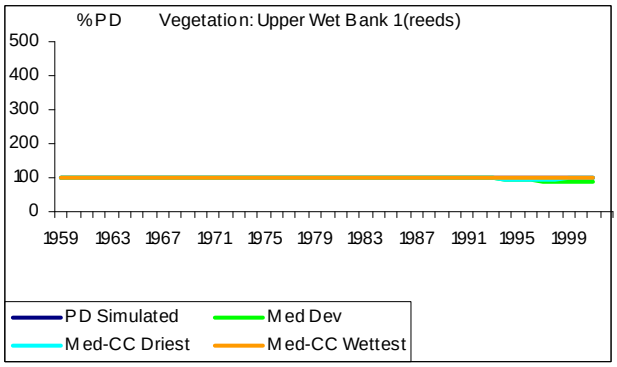
4.3.3 Upper wet bank 1 (reeds)

(Outer edges of the mainstream, beyond inner margin. Emergent vegetation with roots generally wet, but can withstand being out of water. Moving water.)- Phragmites australis

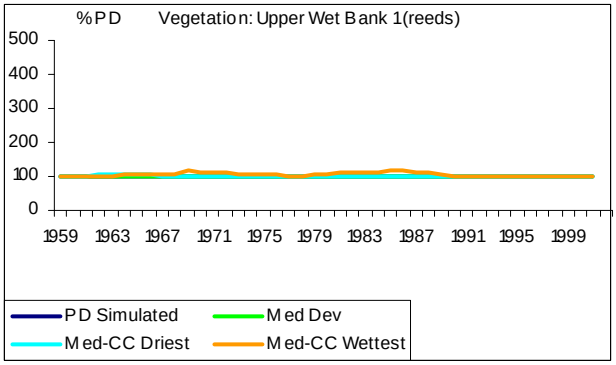
Site 1: Cubango River @ Capico



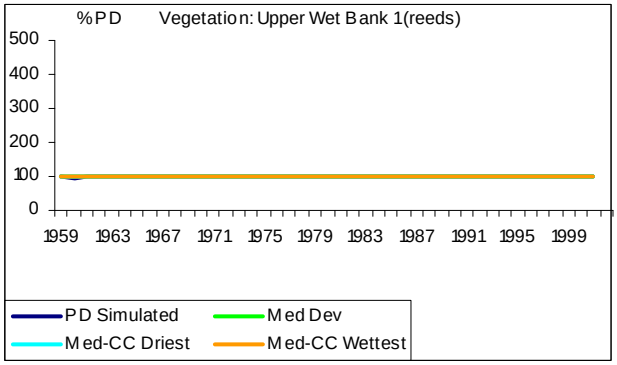
Site 2: Cubango River @ Mucundi



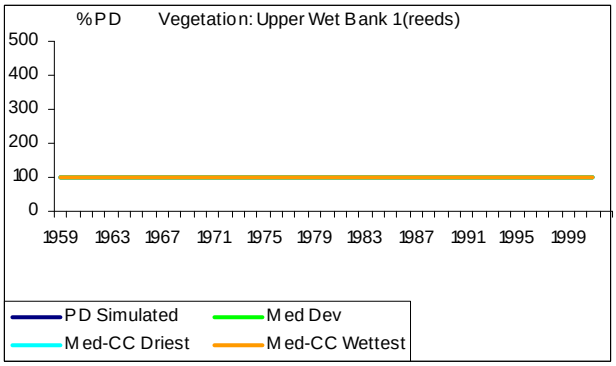
Site 3: Cuito River @ Cuito Cuanavale



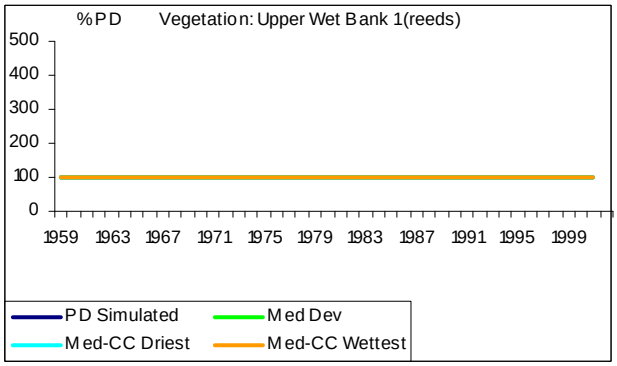
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

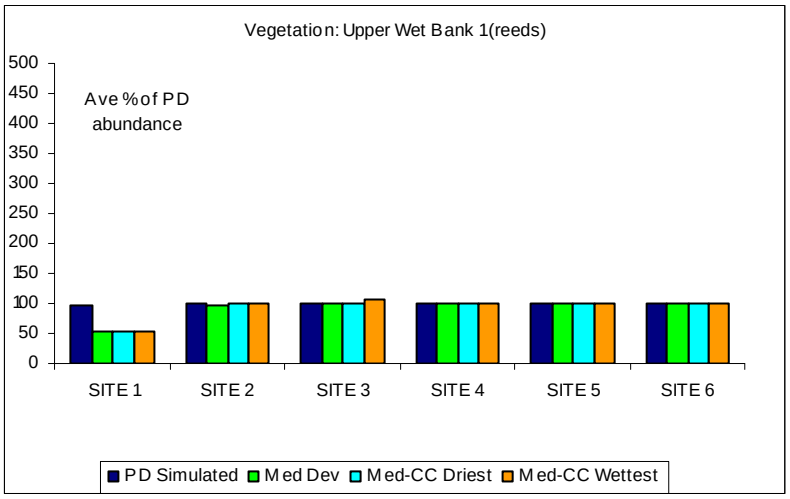


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Water depth (>2 m?) inhibits growth in channel. Declines in dry season flows will encourage colonisation of channel bottom with some die-off of the upper margin of reed bed. Flood season has little impact, but new growth could decrease in strong floods.



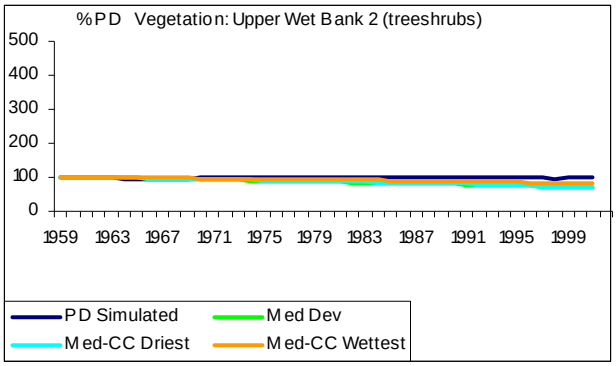
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

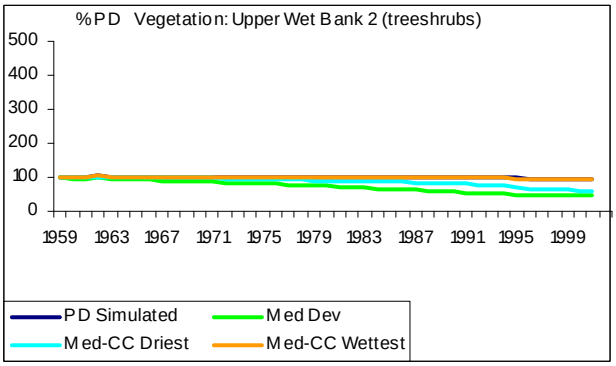
4.3.4 Upper wet bank 2 (treeshrubs)

(Wetted edge of main channel (or river islands) at high flow. Higher than Lower Wet Bank. Trees & shrubs typical of riparian zone. Can be submerged for short periods)- Searsia (Rhus), Syzigium etc.

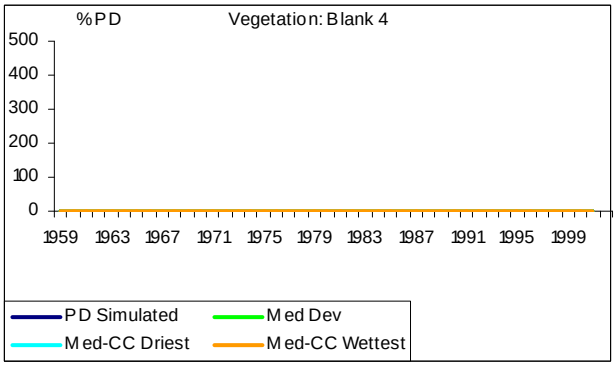
Site 1: Cubango River @ Capico



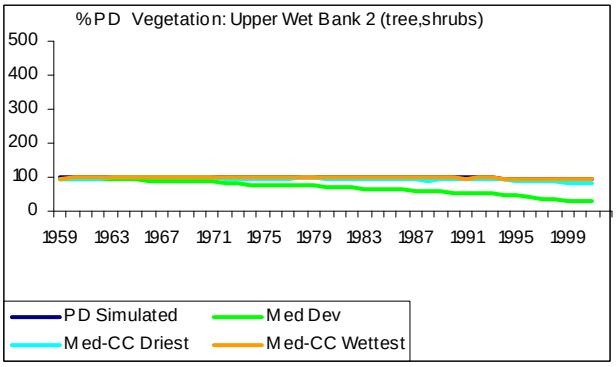
Site 2: Cubango River @ Mucundi



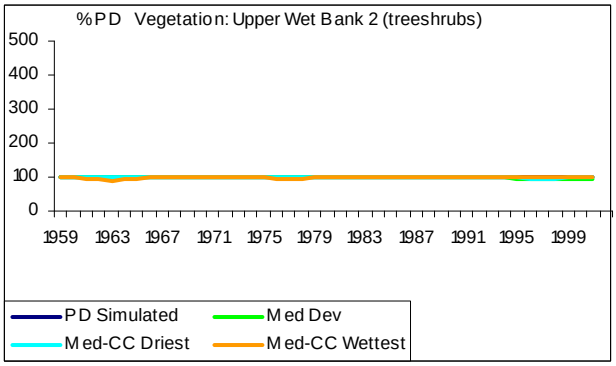
Site 3: Cuito River @ Cuito Cuanavale



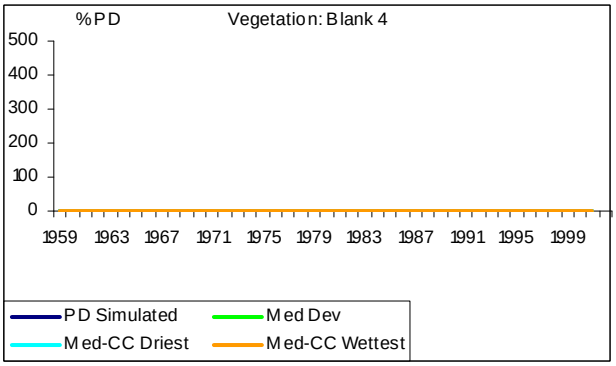
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

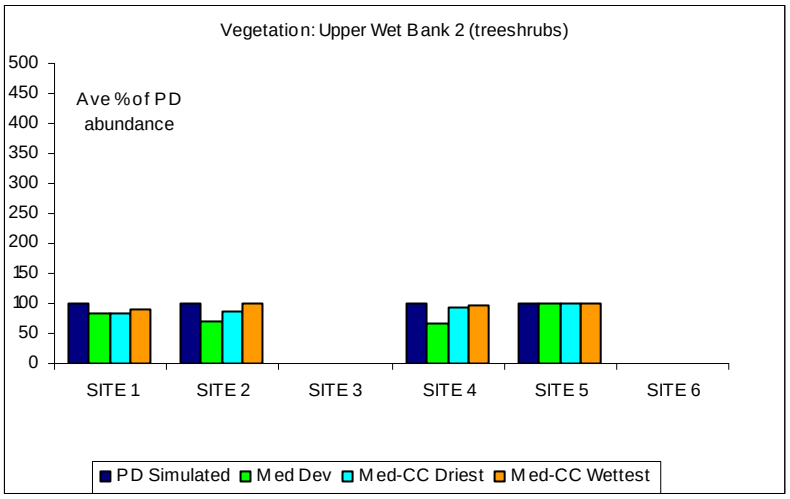


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Can withstand inundation, but too long (>3 months?) will kill trees. Smaller floods will allow colonisation by terrestrial species on the outer edge. These wetbank trees will be squeezed into a smaller zone, decreasing cover. Too long a dry season will reduce recruitment and adult vigour.



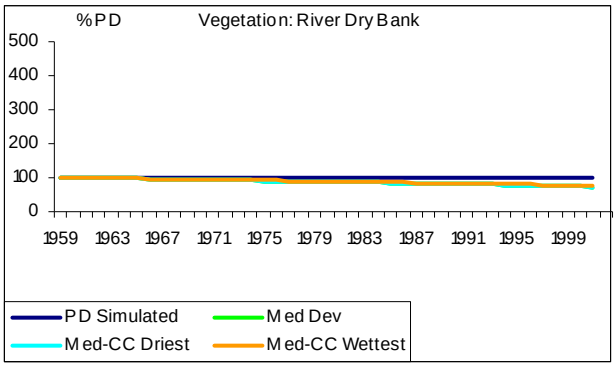
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

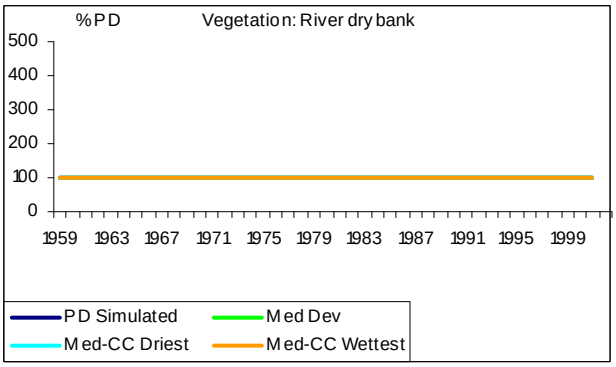
4.3.5 River dry bank

(Riparian woodlands found on the high dry bank of river channels.)- Diospyros mespiliformis, with Acacia nigrescens, Combretum imberbe, Ficus sycomorus.

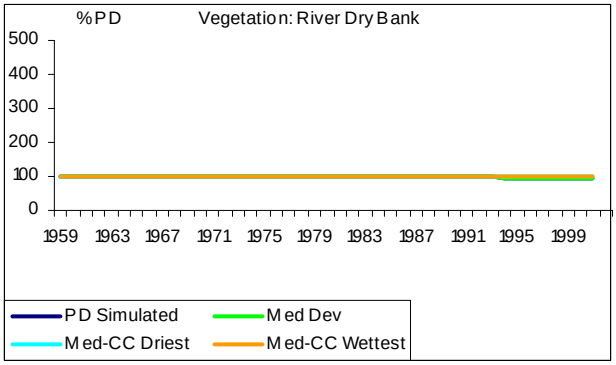
Site 1: Cubango River @ Capico



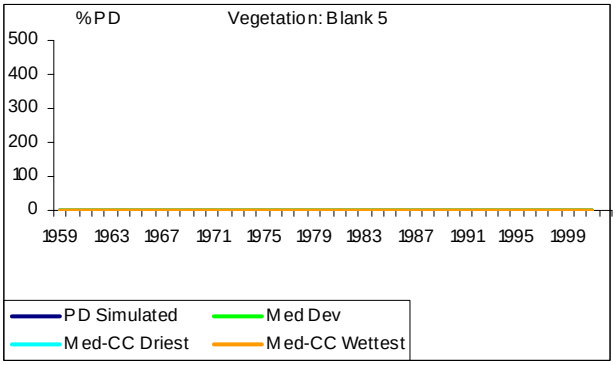
Site 2: Cubango River @ Mucundi



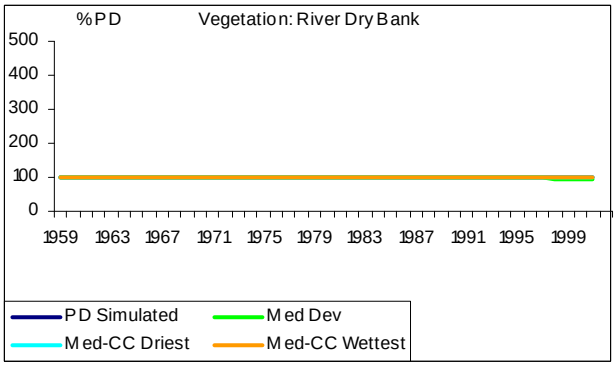
Site 3: Cuito River @ Cuito Cuanavale



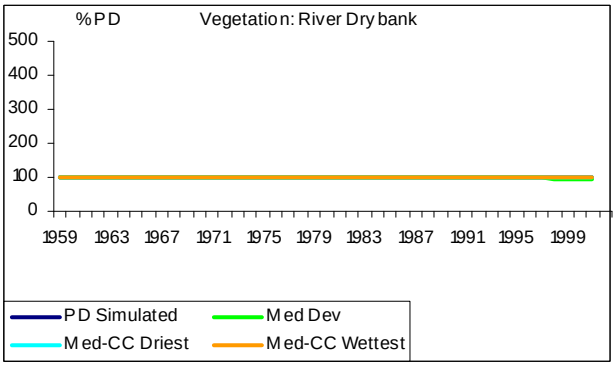
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

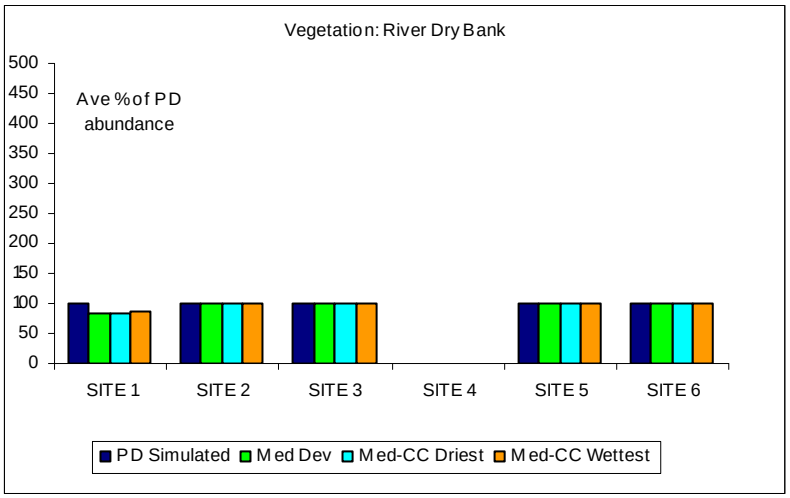


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Stabilises bank. Adults will decrease with very low dry season flow as water table may drop below reach of roots. Seedlings will decline with shorter flood seasons because of lower soil moisture levels. Decline in community could take up to 3 - 4 decades.



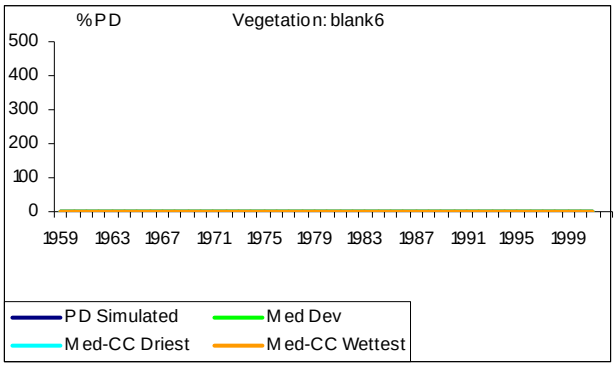
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

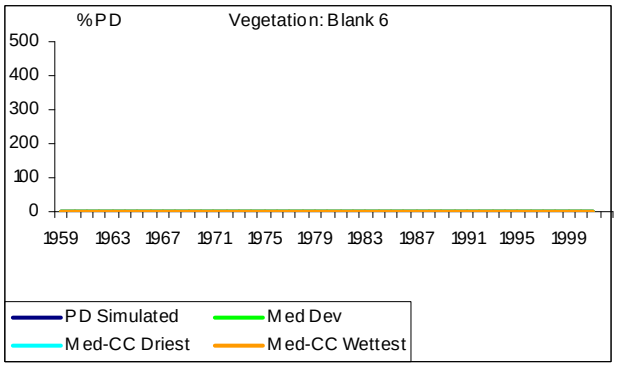
4.3.6 Floodplain residual pools, open water

(Permanent floodplain pools. Connected to river during high flow but retain water at normal low flow)- Nymphaea, Nymphoides, Lagarosiphon, Trapa

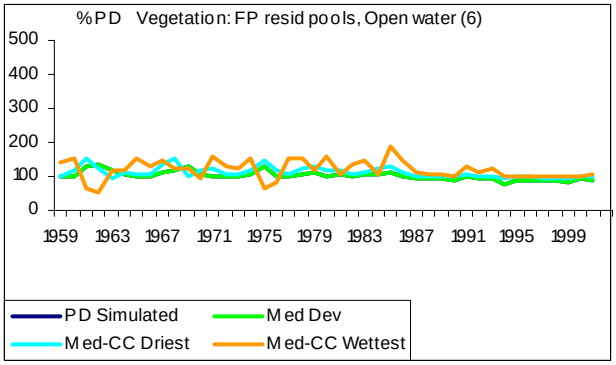
Site 1: Cubango River @ Capico



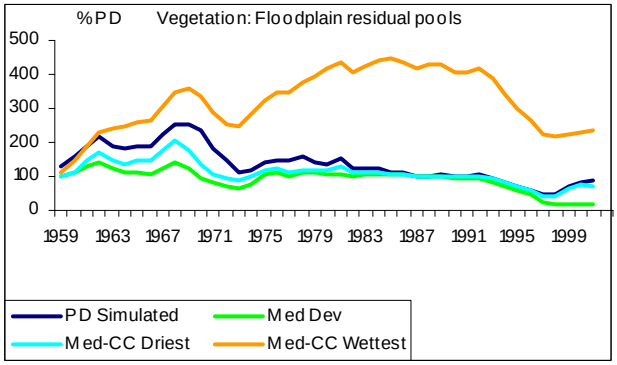
Site 2: Cubango River @ Mucundi



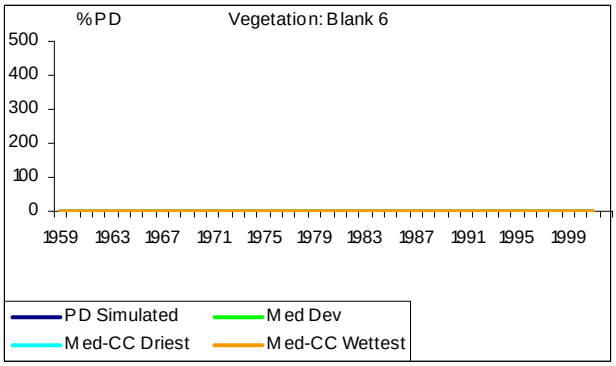
Site 3: Cuito River @ Cuito Cuanavale



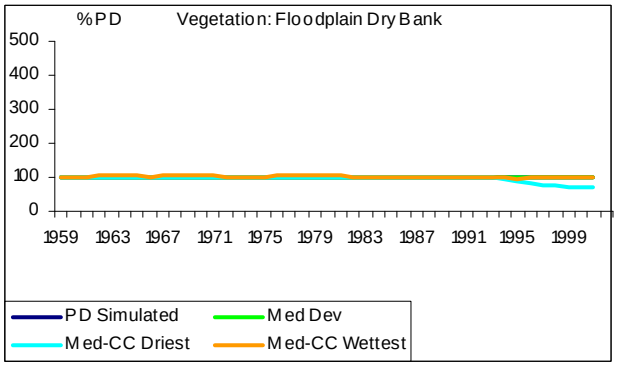
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

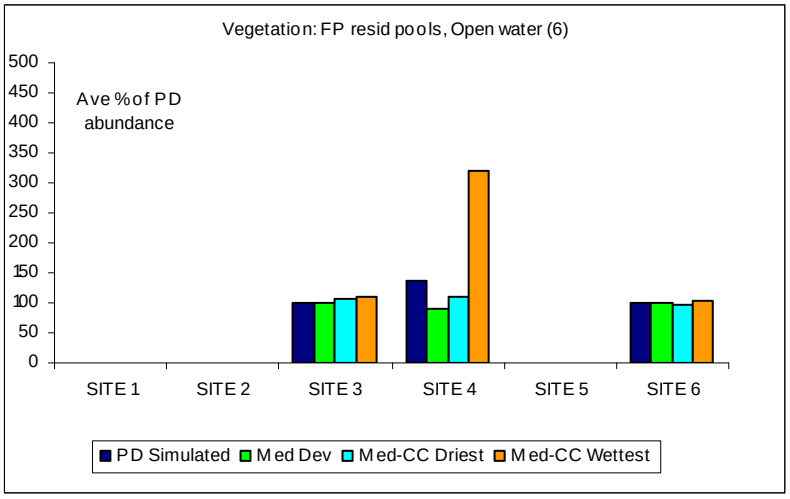


Site 6: Okavango River @ Pan Handle



Summary change per scenario

These are permanent pools that are replenished in the flood. With no flooding, they will decrease in size due to evaporation. With larger floods they could increase in size.



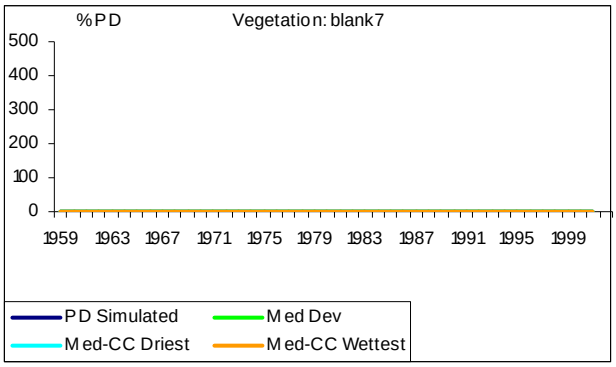
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

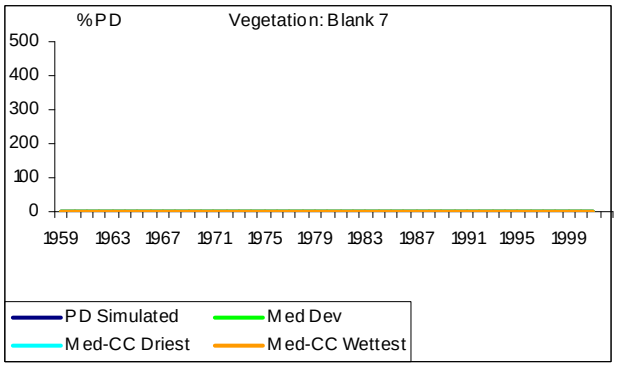
4.3.7 Lower floodplain

(Lower floodplain with long inundation. The deeper sections of channels between scroll bars that flood and dry out seasonally)- Vossia cuspidata with Persicaria, Ludwigia, etc

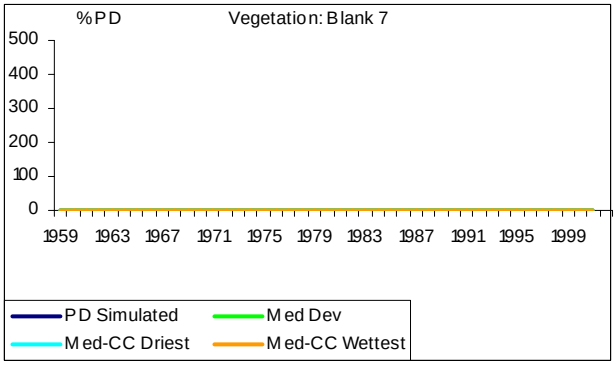
Site 1: Cubango River @ Capico



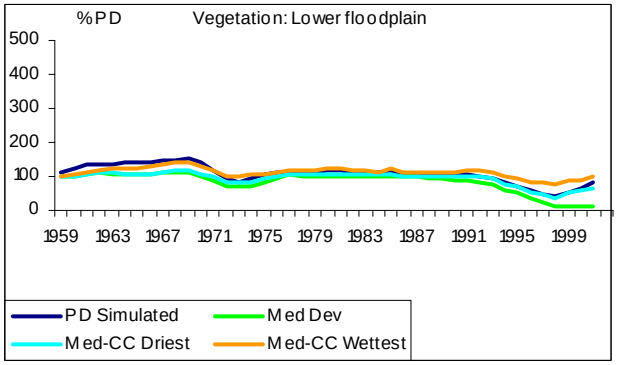
Site 2: Cubango River @ Mucundi



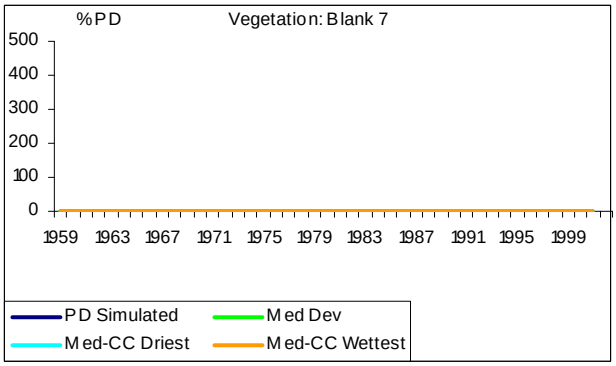
Site 3: Cuito River @ Cuito Cuanavale



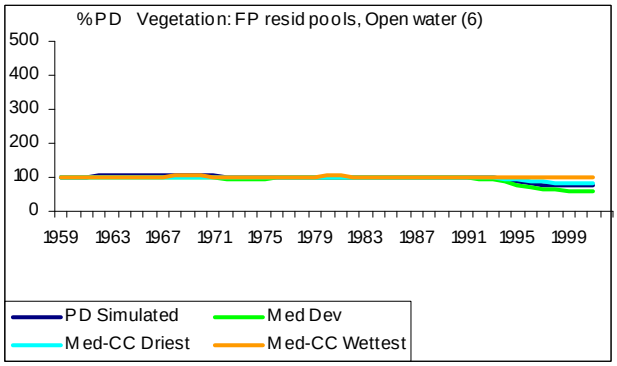
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

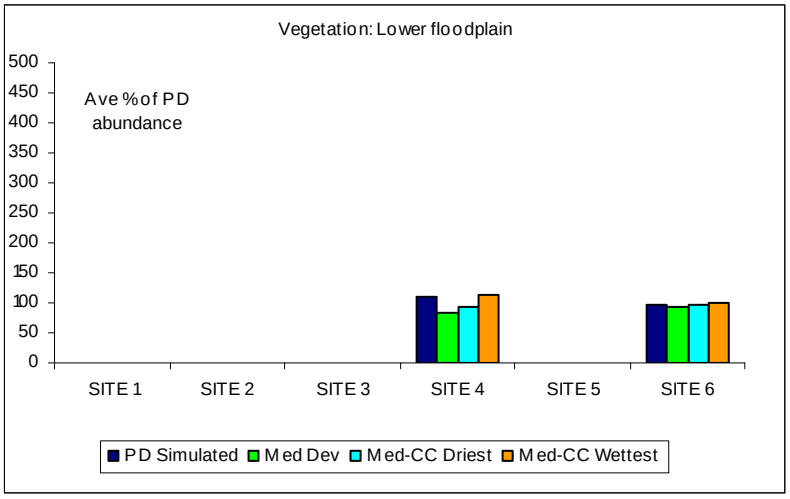


Site 6: Okavango River @ Pan Handle



Summary change per scenario

This is seasonal and dependent on recharge by floods. They mimic the flood levels from year to year. In wet years they will increase in size, in dry years they will decrease.



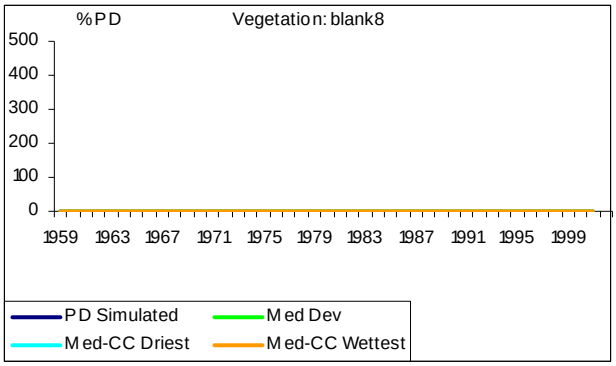
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

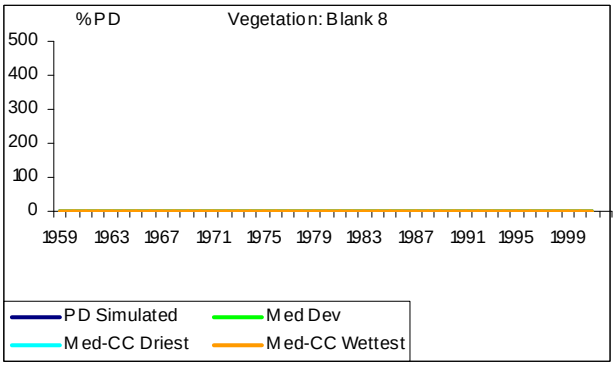
4.3.8 Middle floodplain (grasses)

(Middle floodplain, clay or sand, with short inundation. Large area with thatching and grazing grasses. Includes portions of upper floodplain (but not islands))- Setaria, Panicum, thatching grasses

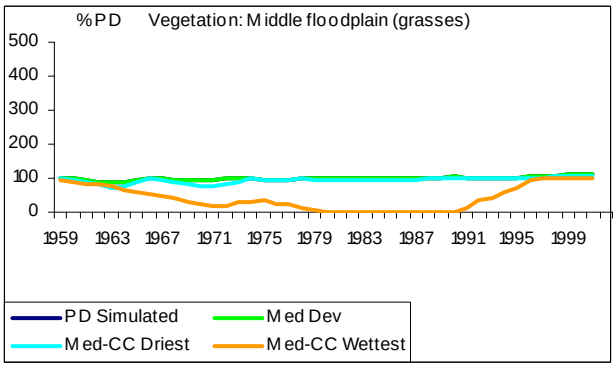
Site 1: Cubango River @ Capico



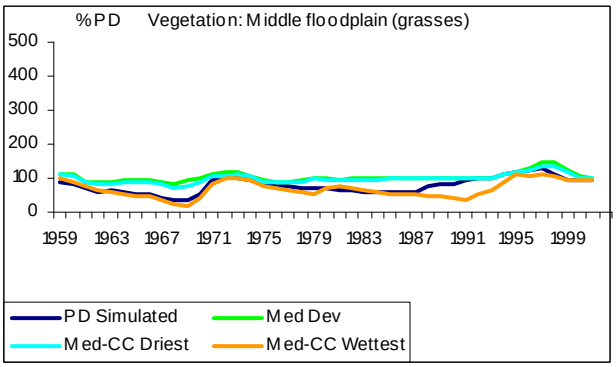
Site 2: Cubango River @ Mucundi



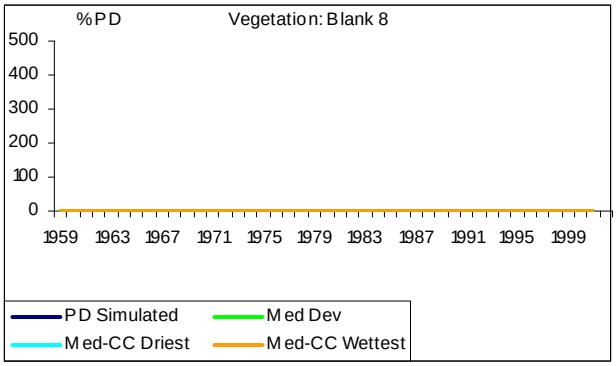
Site 3: Cuito River @ Cuito Cuanavale



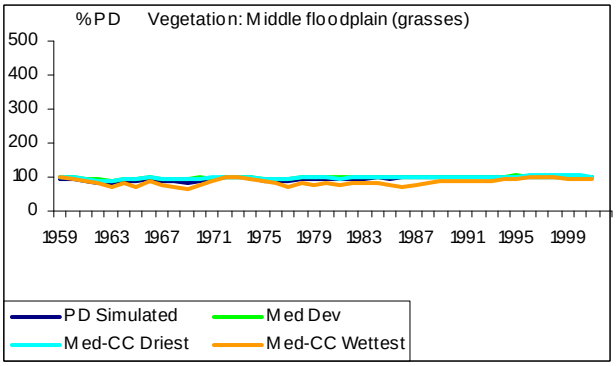
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

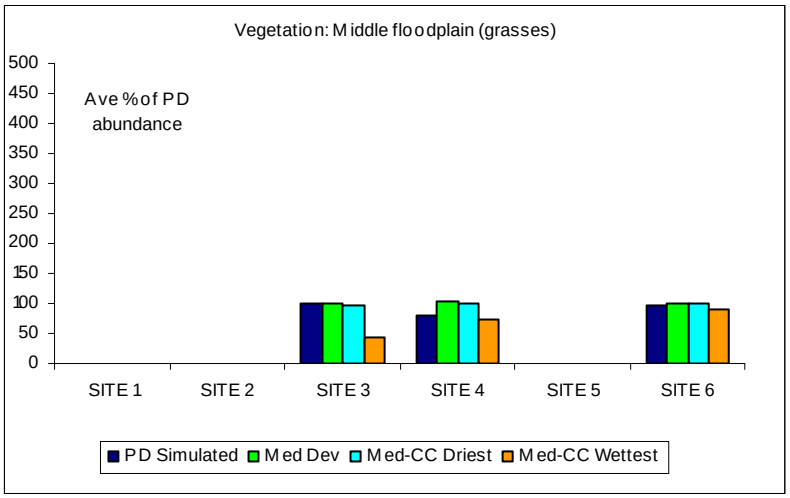


Site 6: Okavango River @ Pan Handle



Summary change per scenario

These are basically terrestrial grasses that can withstand a degree of inundation in the wet season. With a longer wet season, there will be a decrease in area of these plants, and vice versa. Flooding during growing season reduces productivity



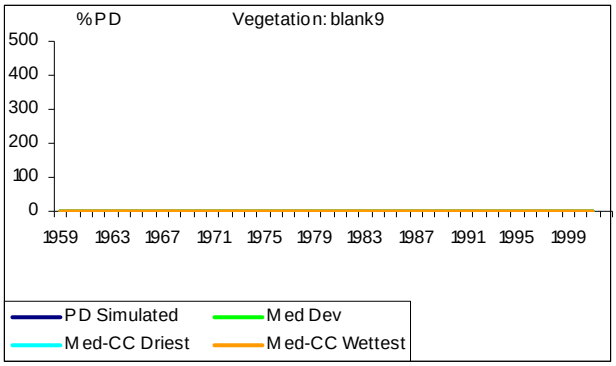
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

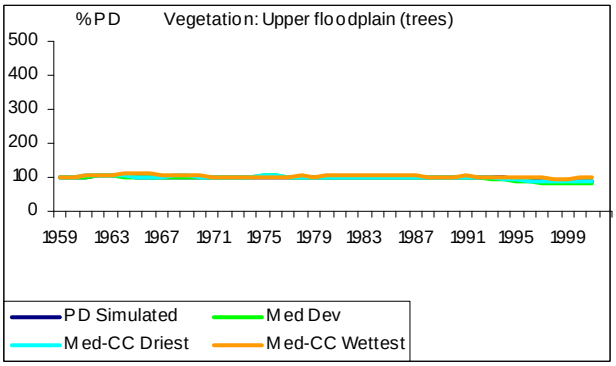
4.3.9 Upper floodplain (trees,rhus)

(The highest points on the floodplain. Only inundated during high flow. Grasses, shrubs, a few trees. Equals wildlife secondary floodplain. Therefore is primarily floodplain islands.)- Searsia (Rhus) with Acacia hebeclada, Acacia sieberiana, Diospyros lycioides, grasses

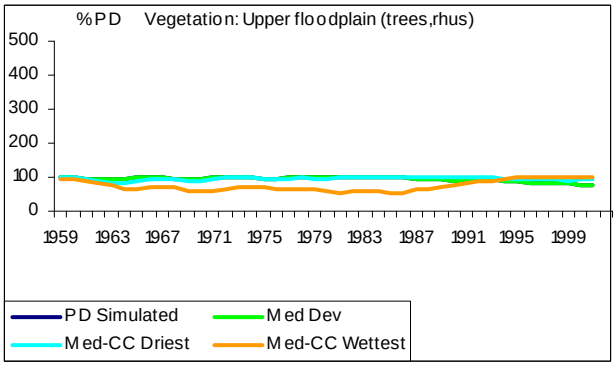
Site 1: Cubango River @ Capico



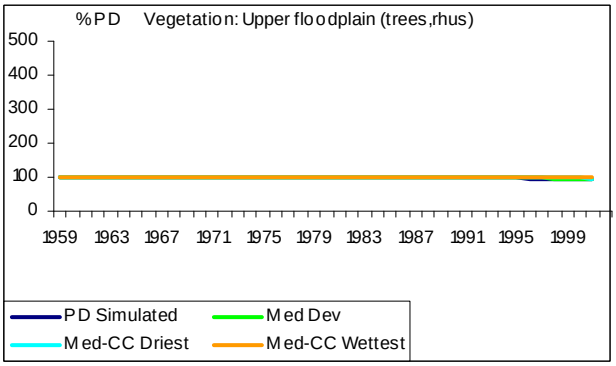
Site 2: Cubango River @ Mucundi



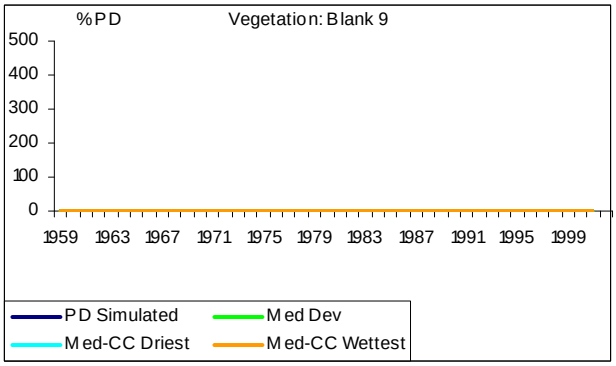
Site 3: Cuito River @ Cuito Cuanavale



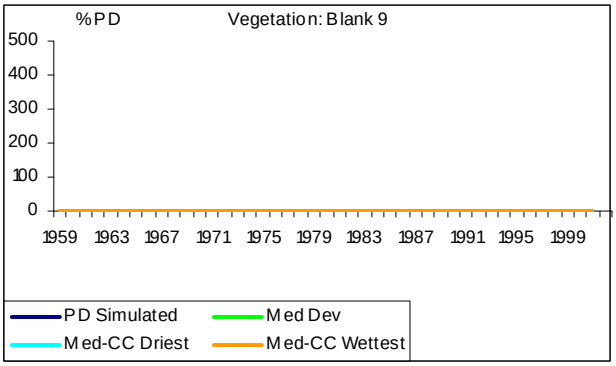
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

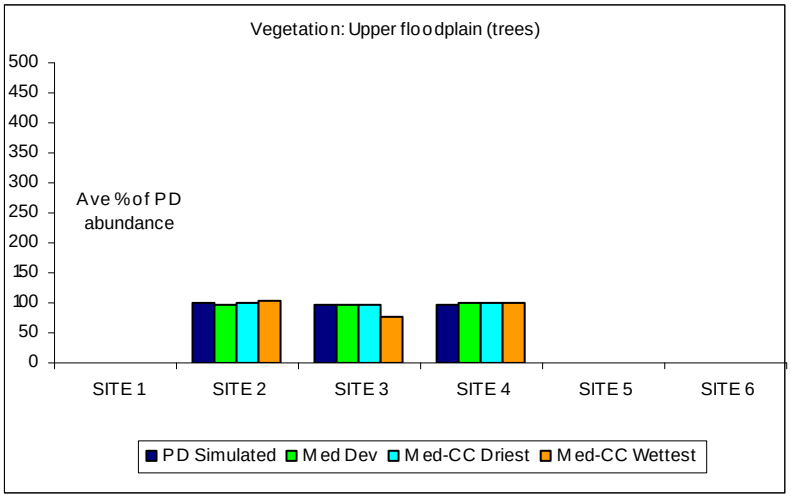


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Seldom inundated. Long inundation is detrimental to these plants. Dependent on some inundation to recharge ground water, and for nutrients.



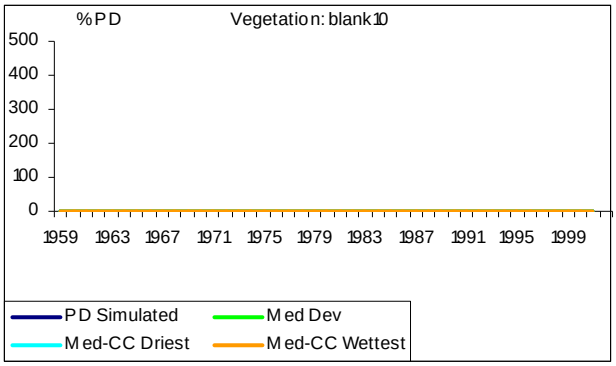
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

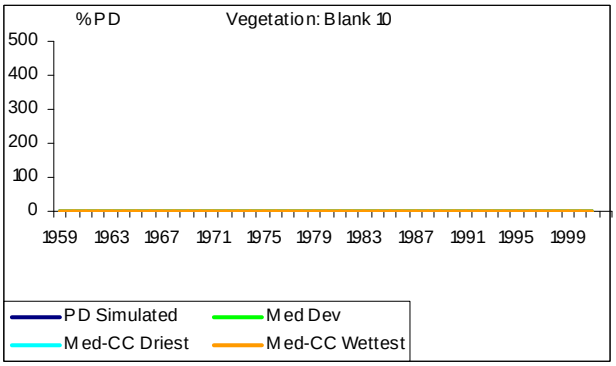
4.3.10 Floodplain dry bank

(Dry river bank on outer edge of floodplain. Seldom to never flooded. Riparian species that need to be close to water.)- Diospyros mespiliformis, with Combretum imberbe, Albizia versicolor, Acacia hebeclada & tortilis, etc

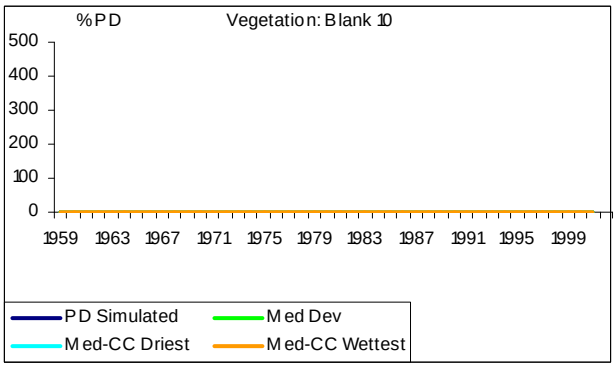
Site 1: Cubango River @ Capico



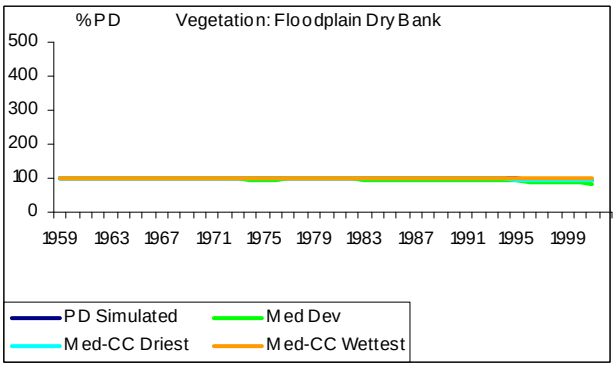
Site 2: Cubango River @ Mucundi



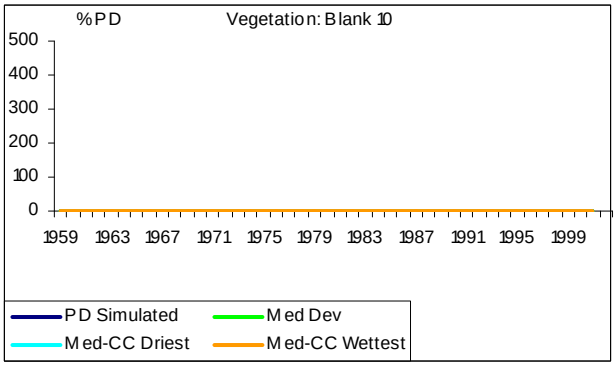
Site 3: Cuito River @ Cuito Cuanavale



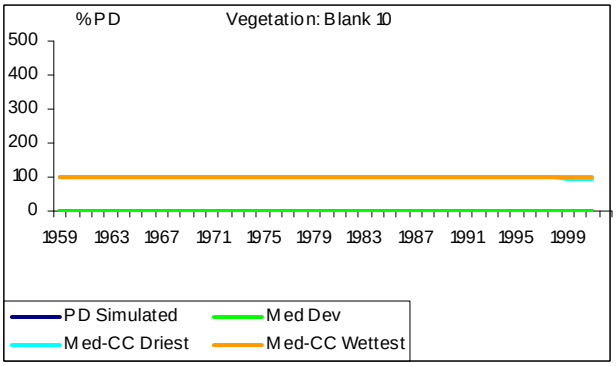
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

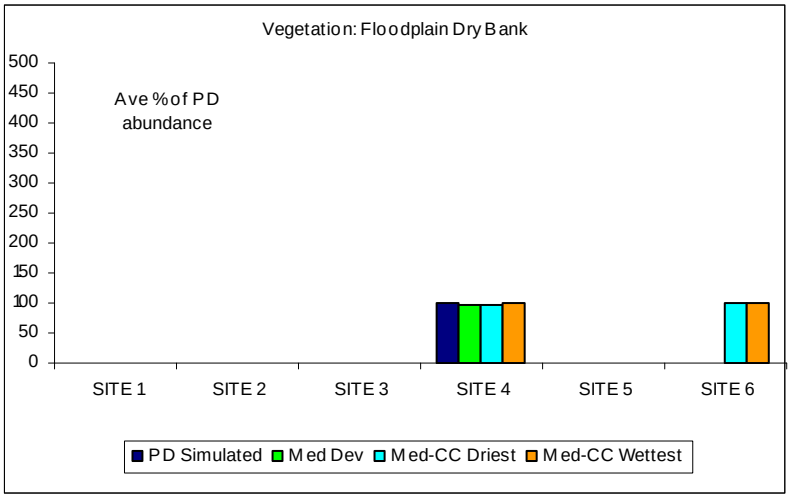


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Stabilises bank. More dependent on floods than river dry bank as water has to cross an extensive floodplain to recharge the ground water. Adults will decrease with low floods and long dry seasons as water table may drop below reach of roots. Seedlings will decline with shorter flood seasons because of lower soil moisture levels. Decline in community could take up to 2 - 3 decades.

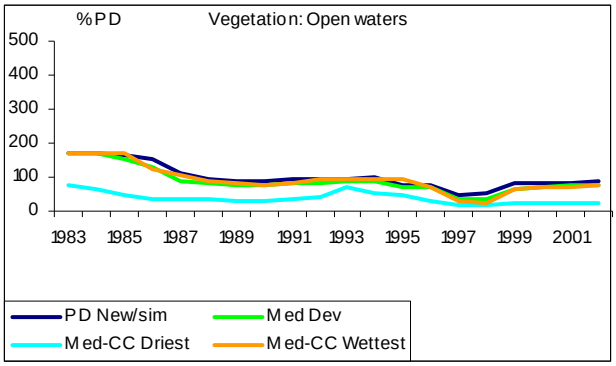


References

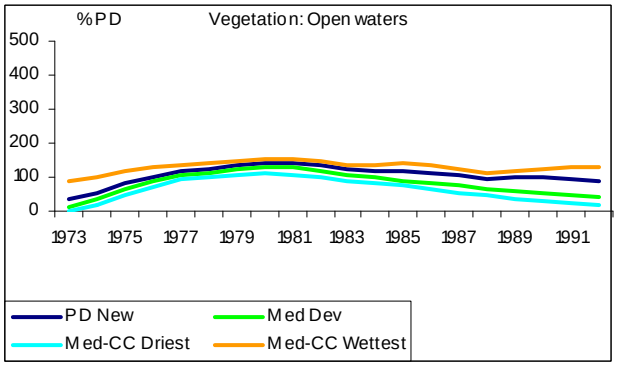
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.11 Open waters

Site 7: Okavango River @ Xakanaxa

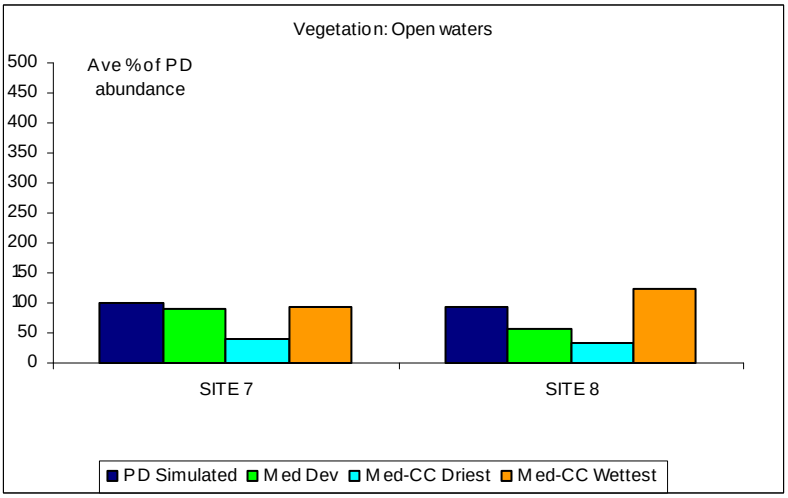


Site 8: Boteti River



Summary change per scenario

Vegetation sensitive to changes in water depth, rate of flow, nutrients and sediments.

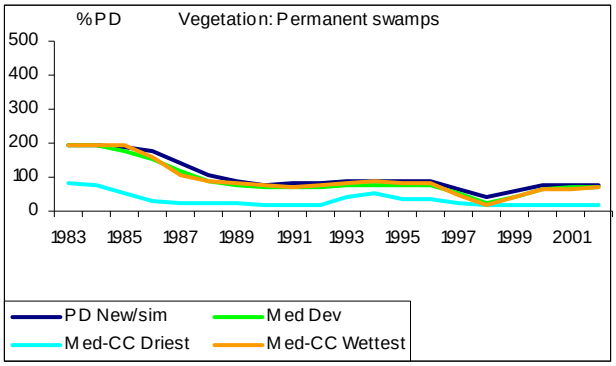


References

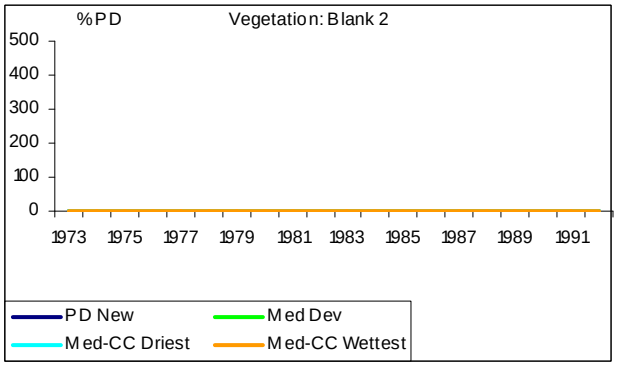
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.12 Permanent swamps

Site 7: Okavango River @ Xakanaxa

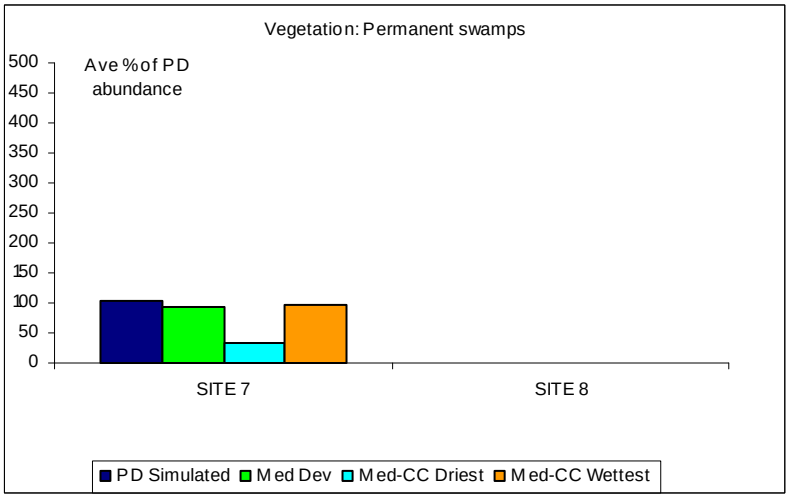


Site 8: Boteti River



Summary change per scenario

More sensitive to soil moisture content. As long as soil is saturated, depth is not important.

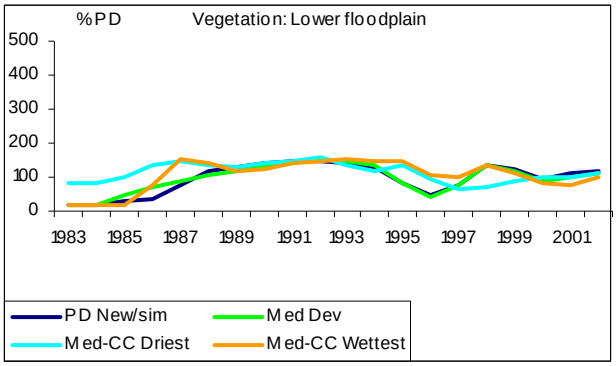


References

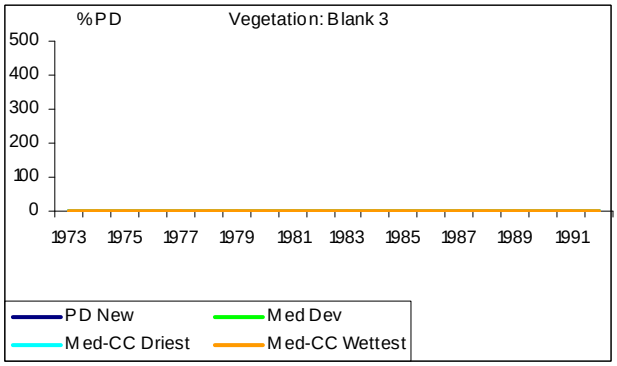
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.13 Lower floodplain

Site 7: Okavango River @ Xakanaxa

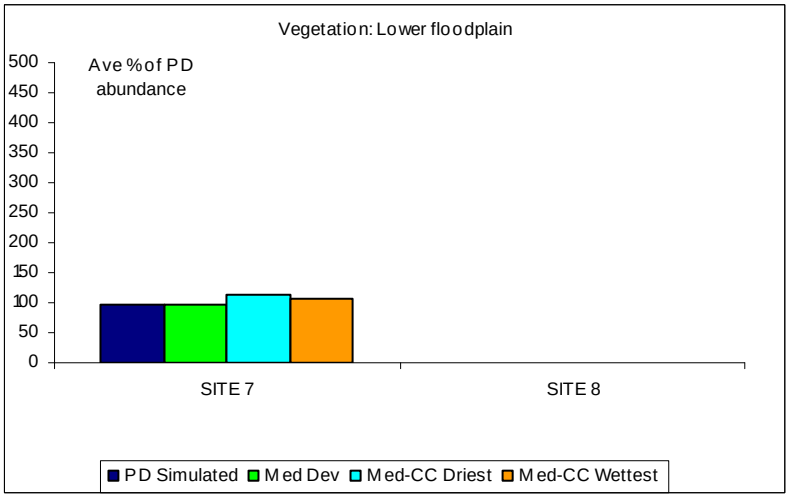


Site 8: Boteti River



Summary change per scenario

Sensitive to duration and frequency of flooding. Long duration of flood correlates with depth of water.

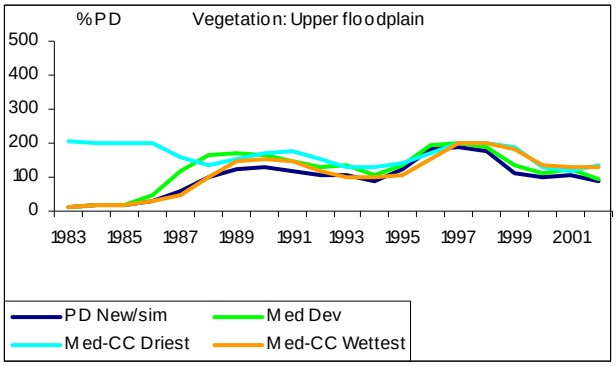


References

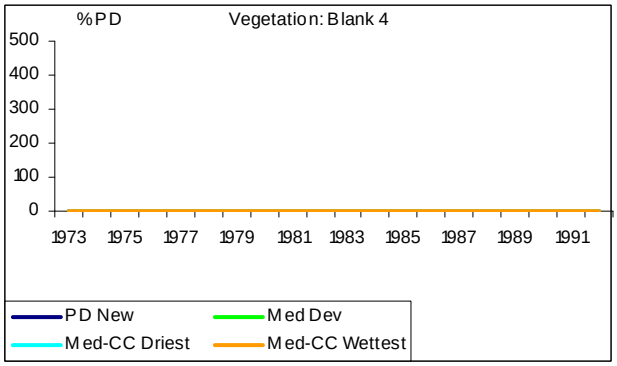
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.14 Upper floodplain

Site 7: Okavango River @ Xakanaxa

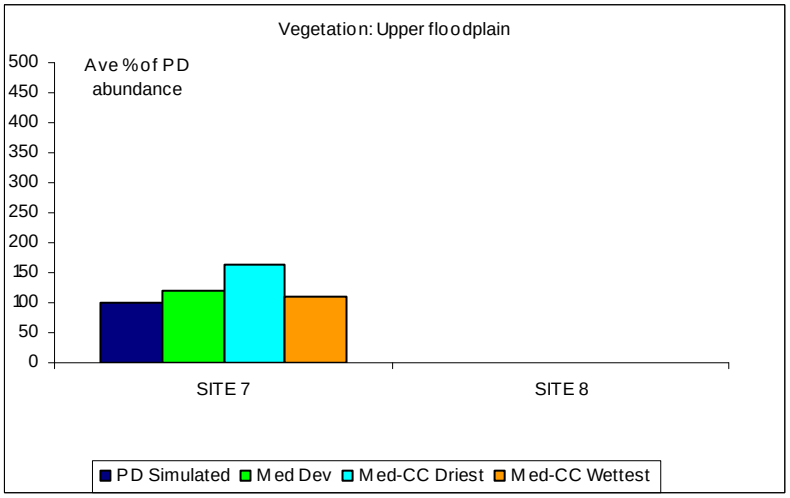


Site 8: Boteti River



Summary change per scenario

Sensitive to duration and frequency of flooding. Long duration of flood correlates with depth of water.

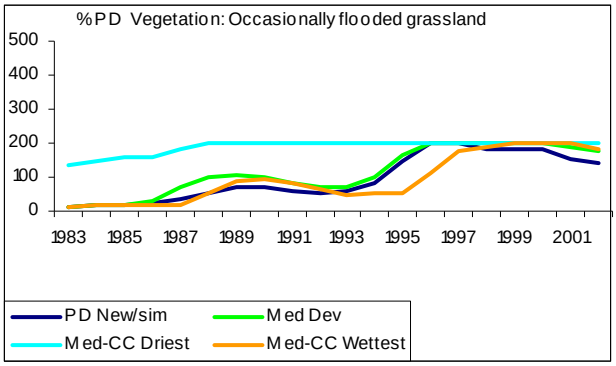


References

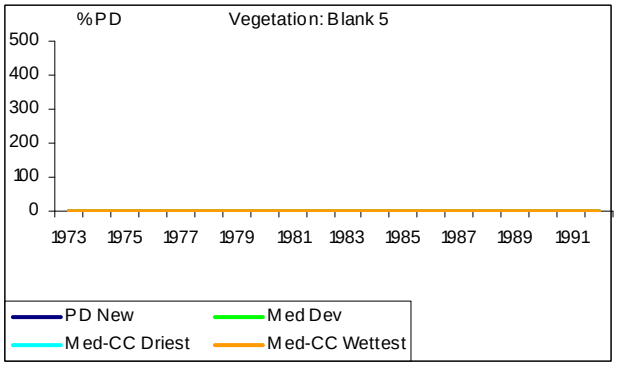
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.15 Occasionally flooded grassland

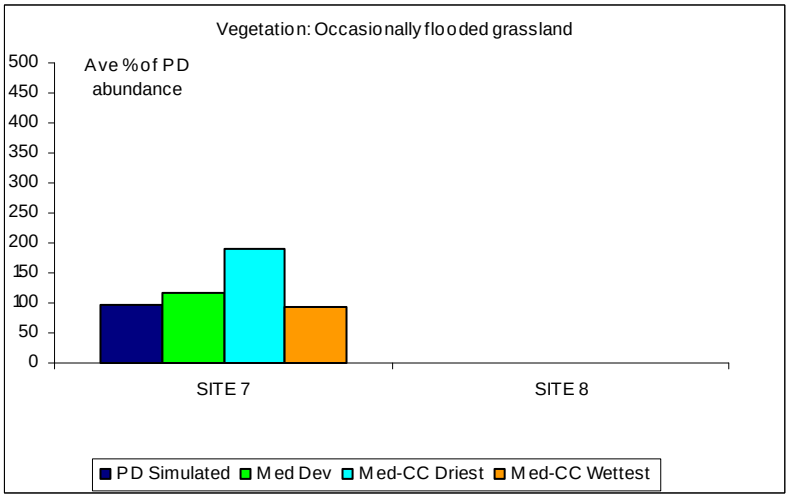
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



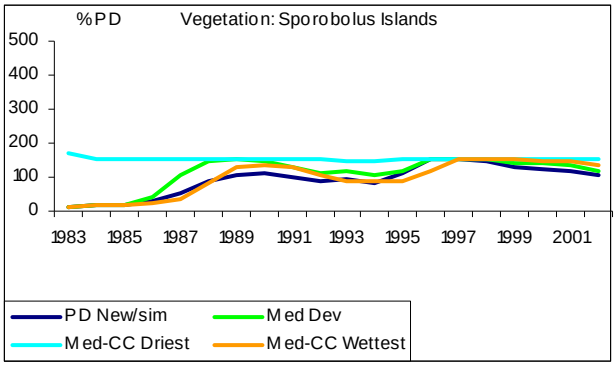
Summary change per scenario
Can be turned into savanna in long, dry periods.



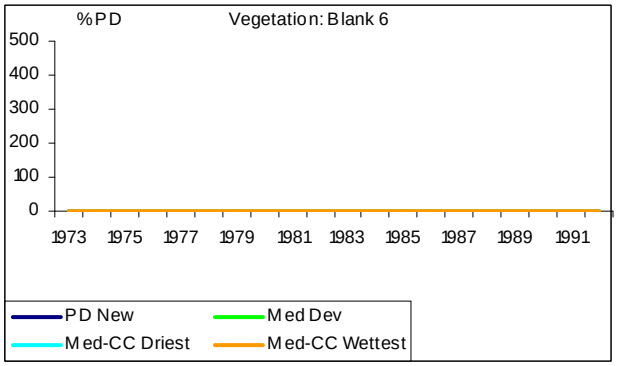
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.16 Sporobolus Islands

Site 7: Okavango River @ Xakanaxa

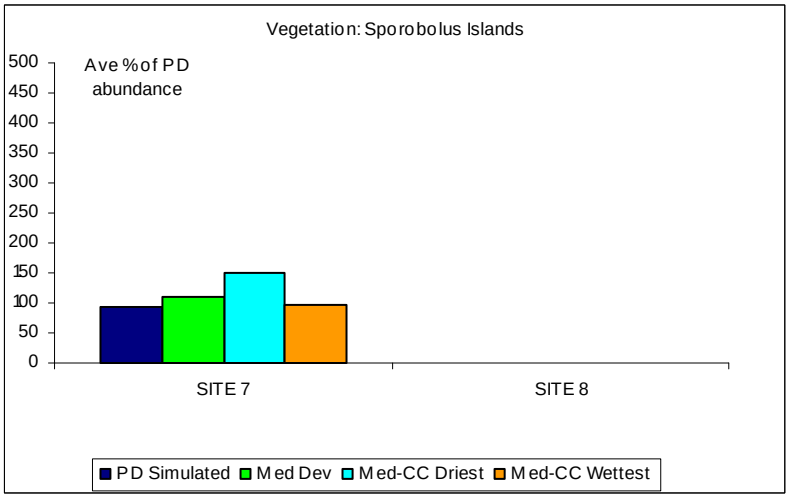


Site 8: Boteti River



Summary change per scenario

They are confined to very elevated areas, and there is a maximum to which they can increase.

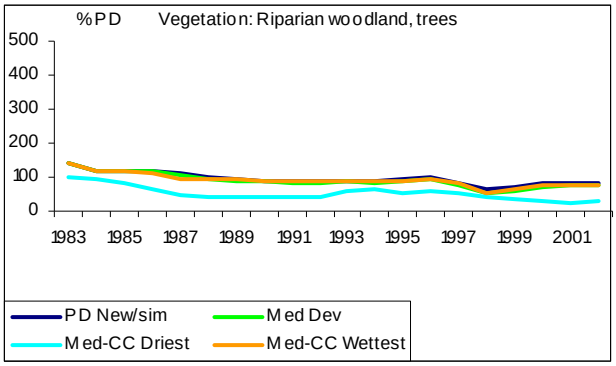


References

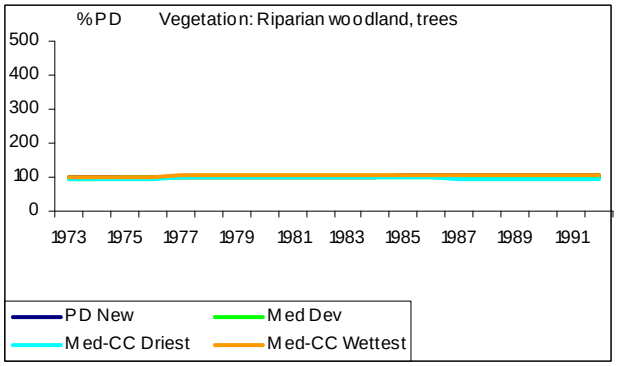
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.17 Riparian woodland, trees

Site 7: Okavango River @ Xakanaxa

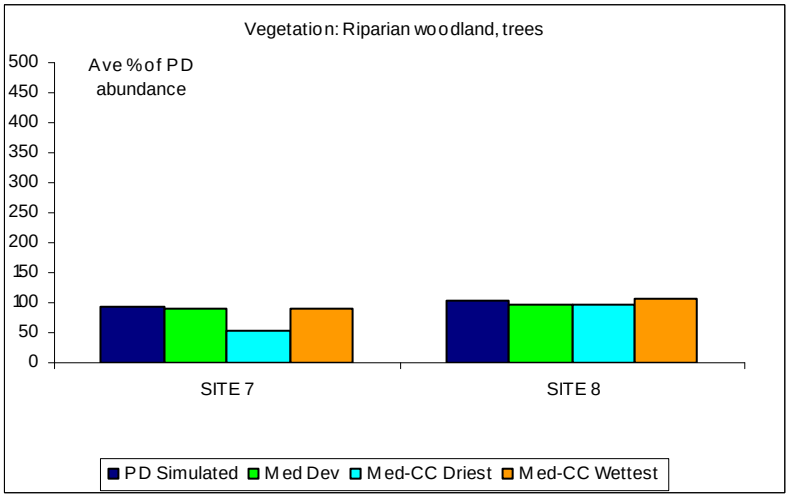


Site 8: Boteti River



Summary change per scenario

Old trees which will not respond immediately to changes in flows, but will gradually decline in successive dry years if groundwater table drops.

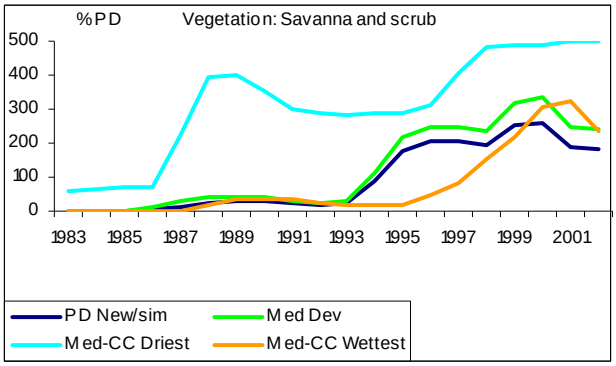


References

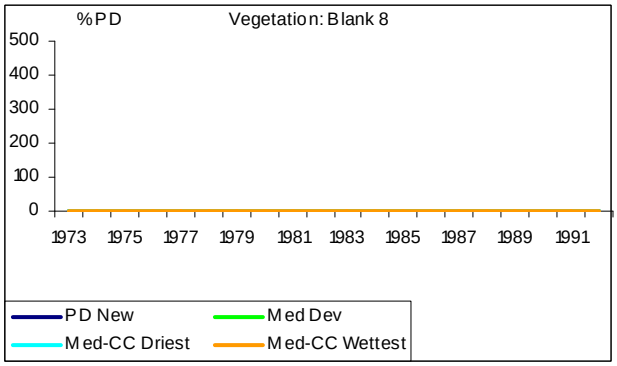
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.18 Savanna and scrub

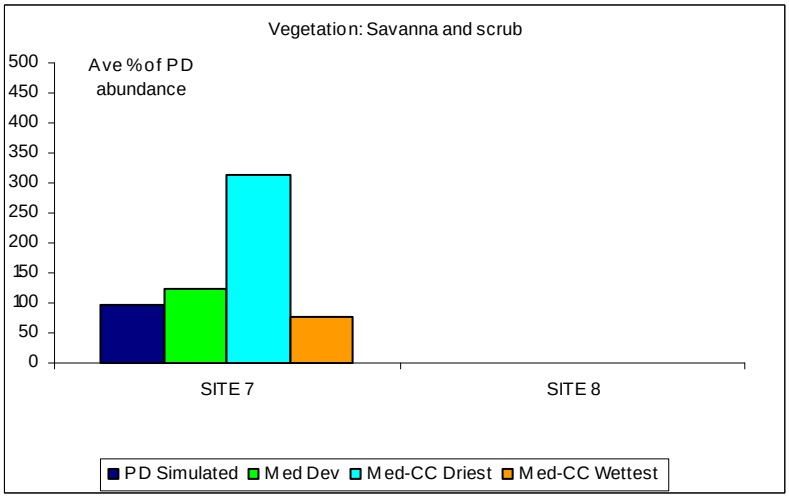
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



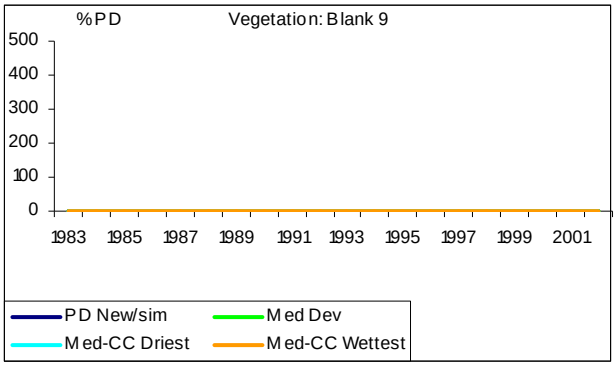
Summary change per scenario
Will increase in dry conditions and can encroach on other wetter habitats.



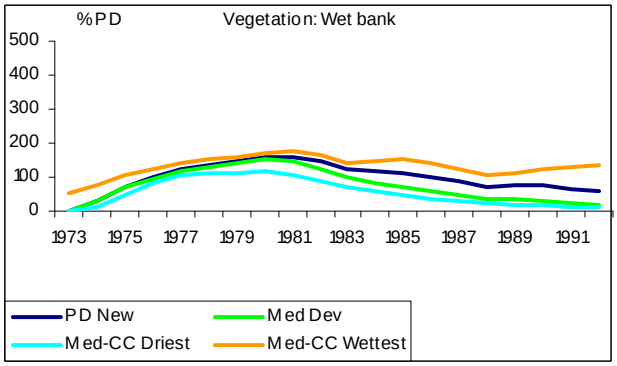
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.3.19 Wet bank

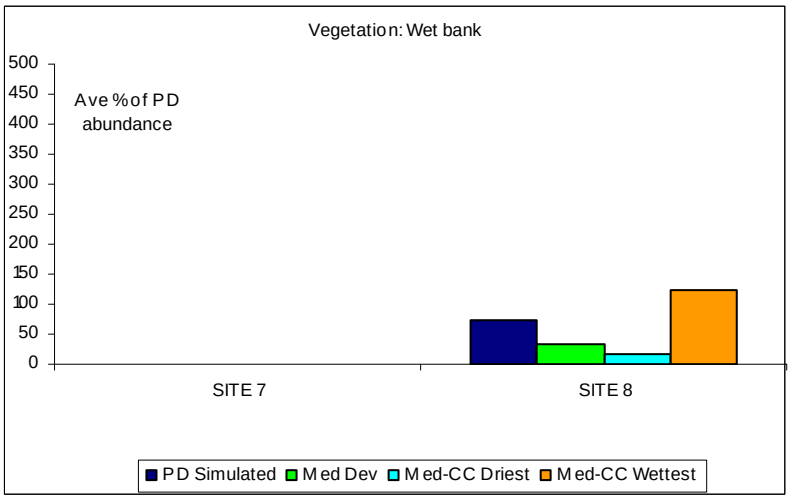
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.4. Macroinvertebrates

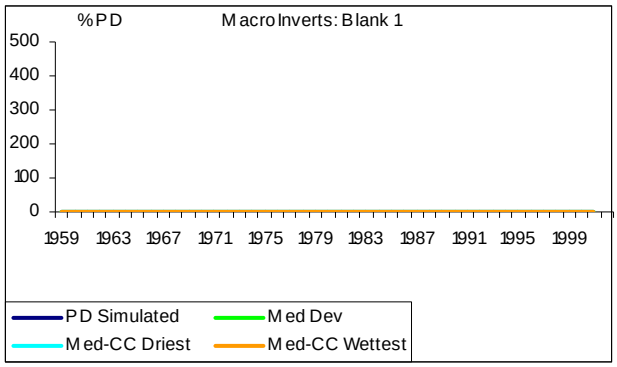
This section provides the time-series for aquatic macroinvertebrate indicators under the flow regime resulting from the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Channel-submerged vegetation
- Channel-marginal vegetation
- Channel-fine sediments
- Channel-cobbles, boulders
- Channel rapid, fast flowing
- Channel-pools
- Floodplain-marginal vegetation
- Floodplain-pools, backwaters
- Mopane woodland-pools.

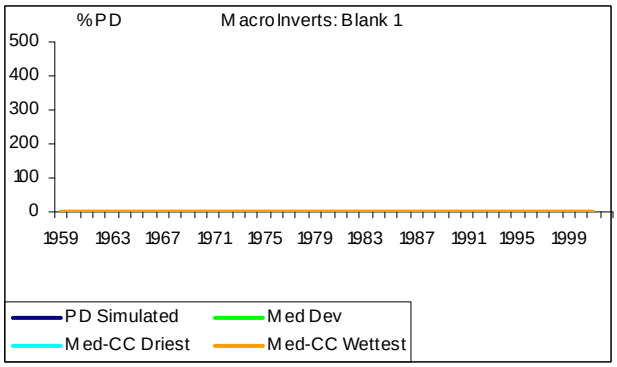
4.4.1 Channel-submerged vegetation

(Channel dwellers in submerged vegetation)- Crustacea (Freshwater shrimps)

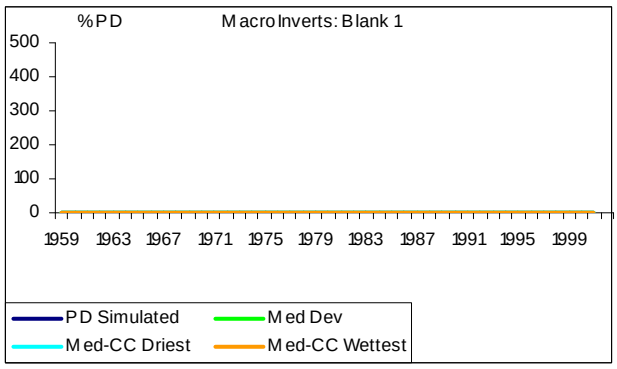
Site 1: Cubango River @ Capico



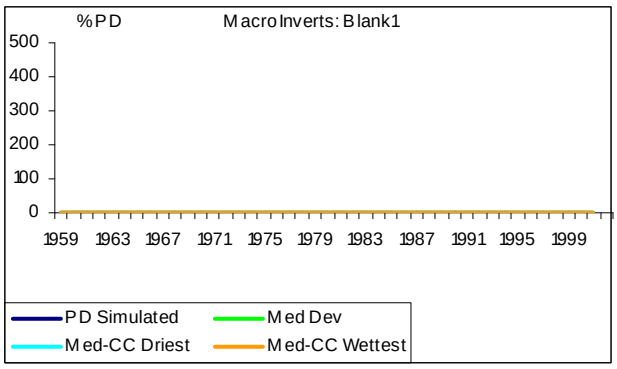
Site 2: Cubango River @ Mucundi



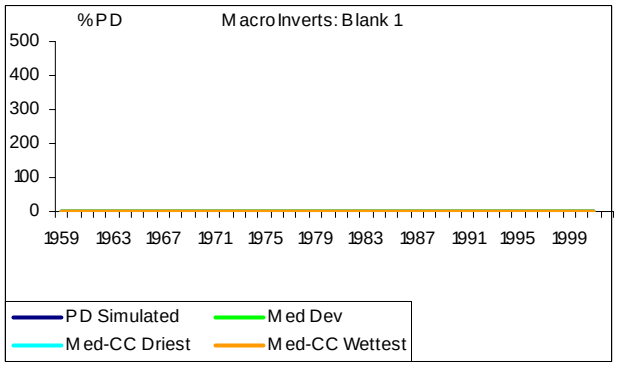
Site 3: Cuito River @ Cuito Cuanavale



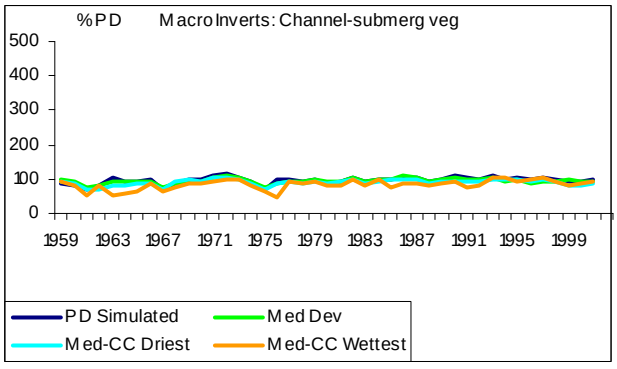
Site 4: Okavango River @ Rundu



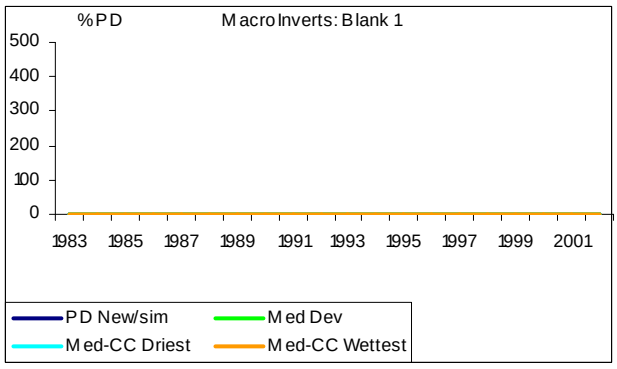
Site 5: Okavango River @ Popa Falls



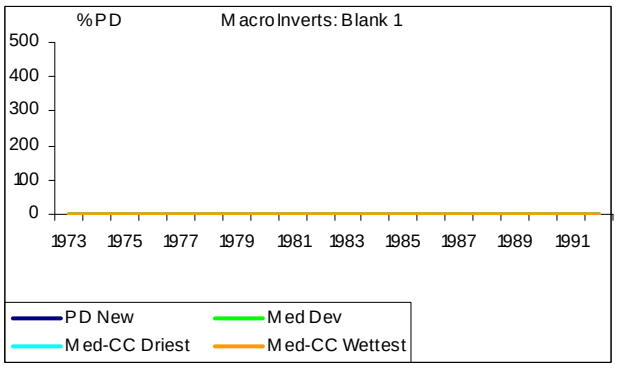
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

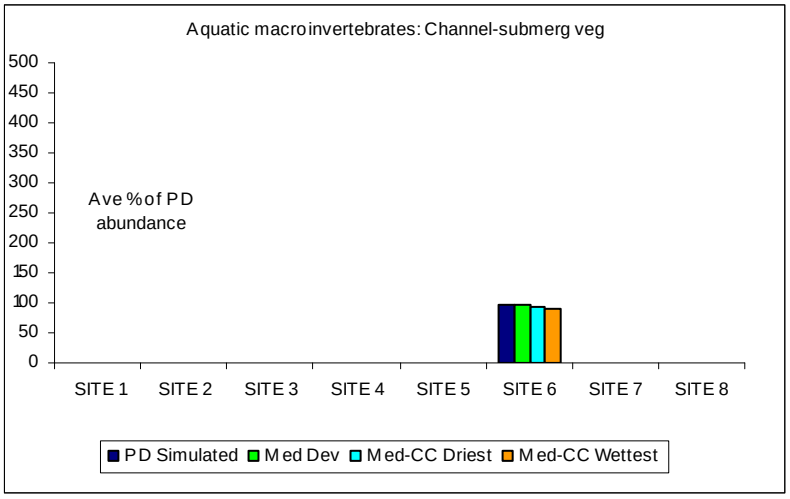


Site 8: Boteti River



Summary change per scenario

Water must always be present. At minimum flow habitat will be greatly reduced leading to population decline as predation increases.



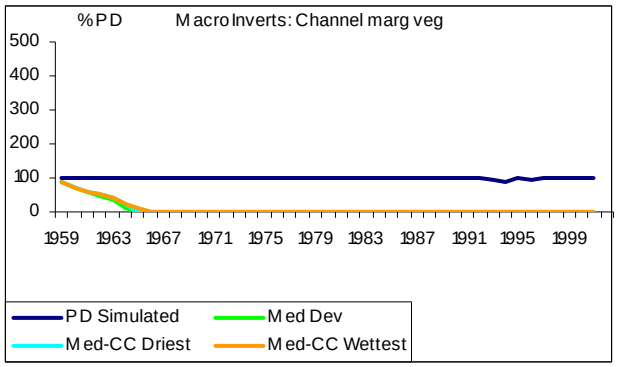
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

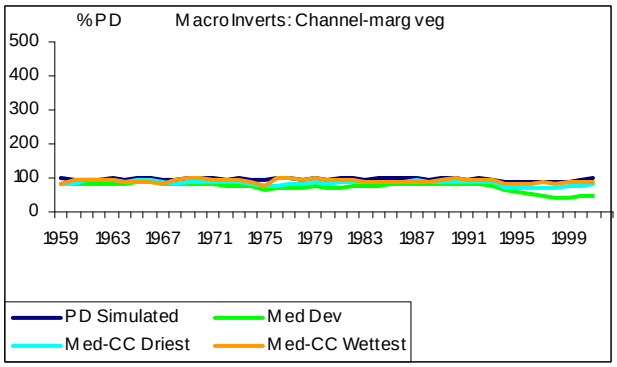
4.4.2 Channel-marginal veg

(Channel dwellers in marginal vegetation)- Caenidae, Tricorythidae

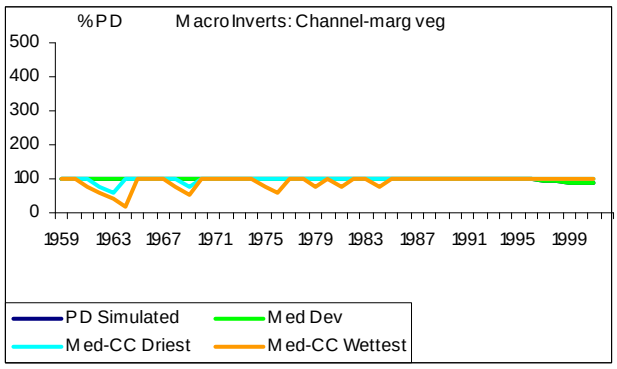
Site 1: Cubango River @ Capico



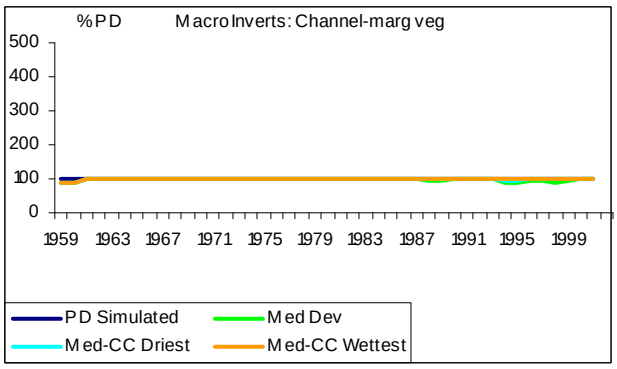
Site 2: Cubango River @ Mucundi



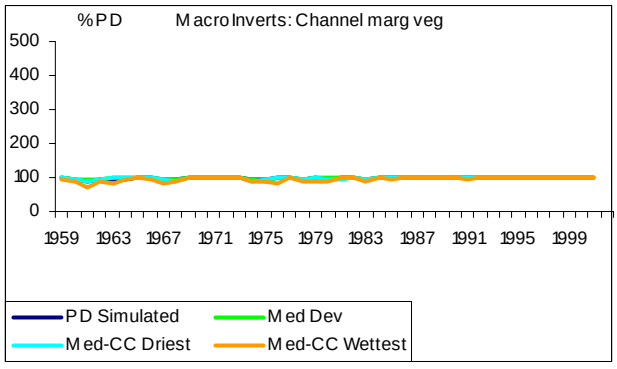
Site 3: Cuito River @ Cuito Cuanavale



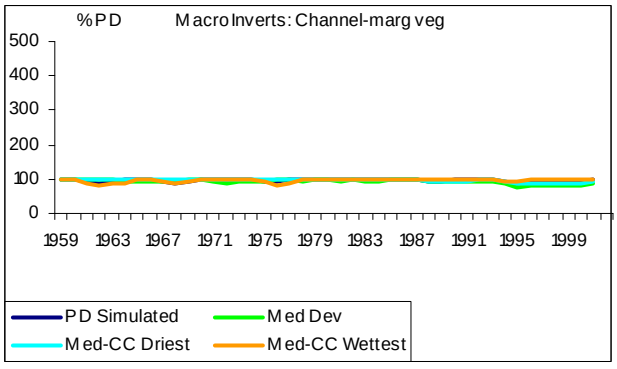
Site 4: Okavango River @ Rundu



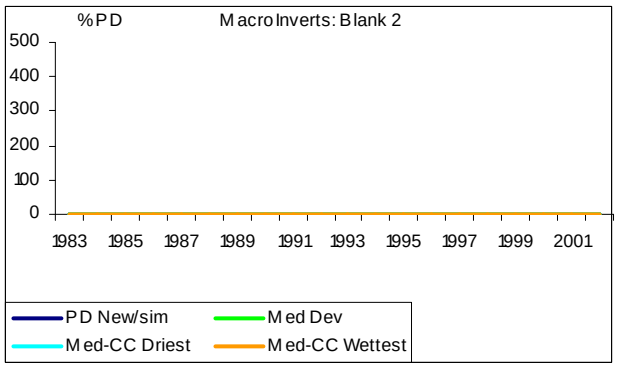
Site 5: Okavango River @ Popa Falls



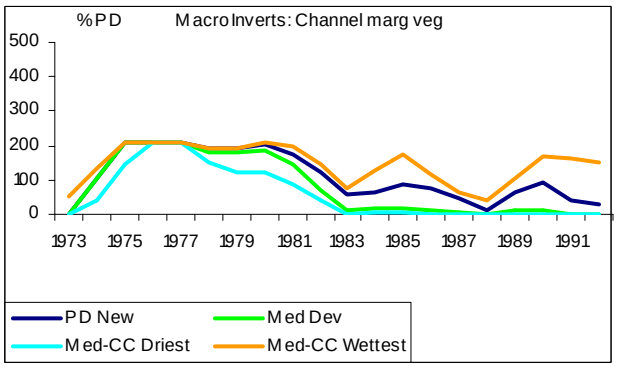
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

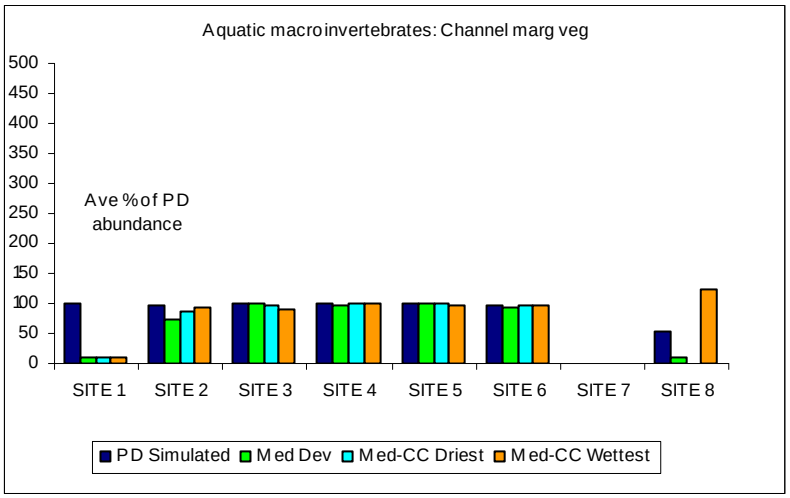


Site 8: Boteti River



Summary change per scenario

Water must always be present. High, long-duration flooding may lead to destruction of habitat and reduction in abundance. Long duration of minimum flows restricted to the river bed may also lead to loss of habitat.



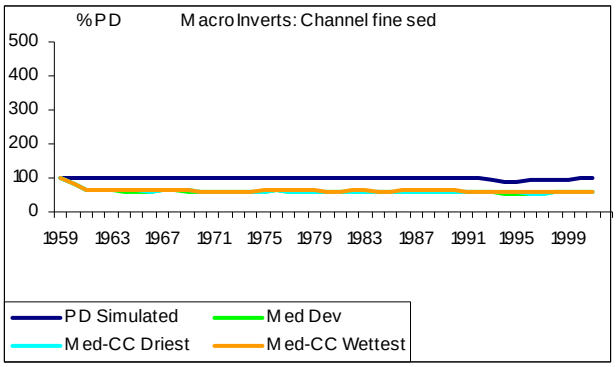
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

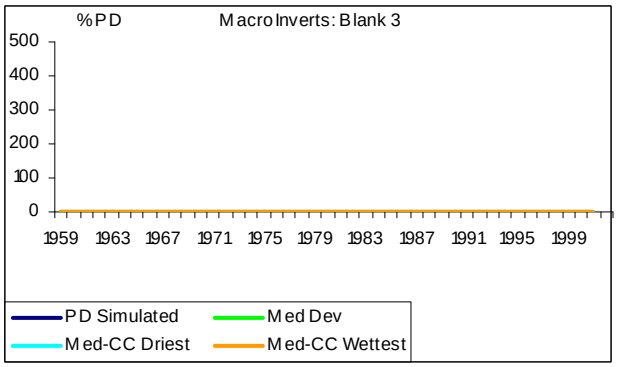
4.4.3 Channel-fine sed

(Channel dwellers in fine sediment)- Unionidae, Sphaeridae

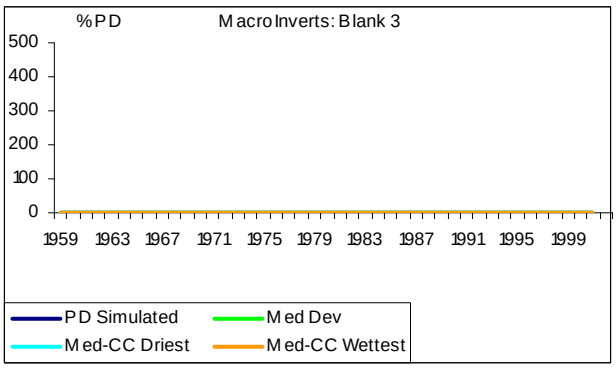
Site 1: Cubango River @ Capico



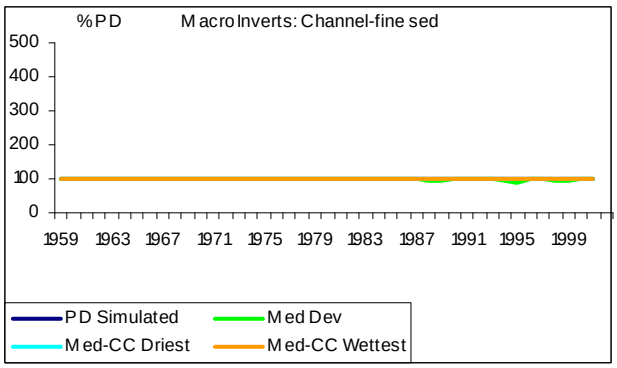
Site 2: Cubango River @ Mucundi



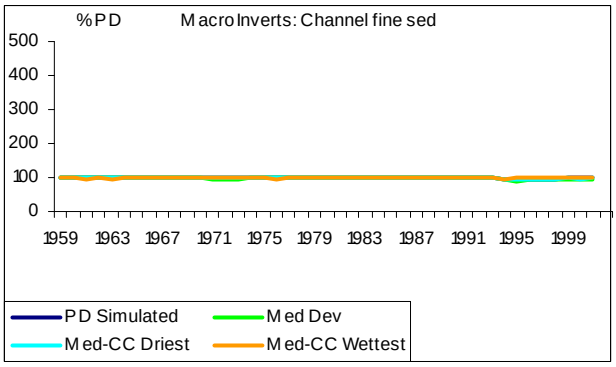
Site 3: Cuito River @ Cuito Cuanavale



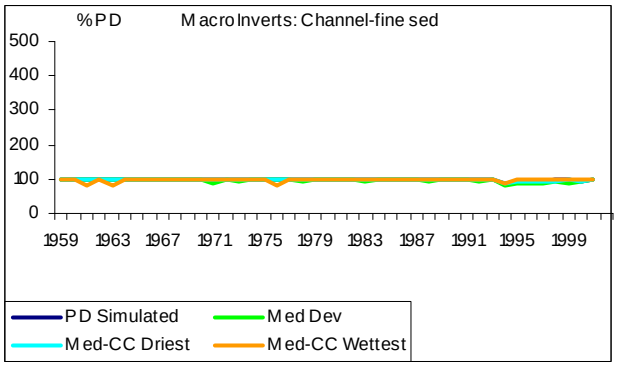
Site 4: Okavango River @ Rundu



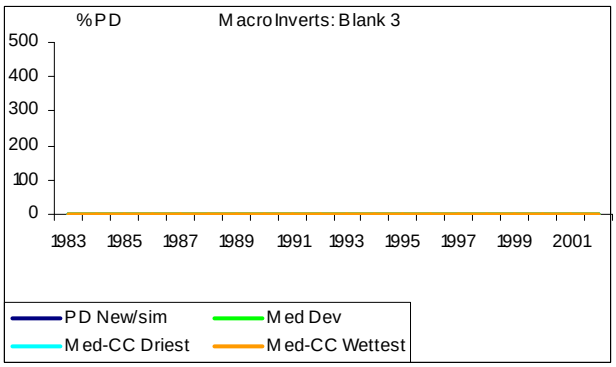
Site 5: Okavango River @ Popa Falls



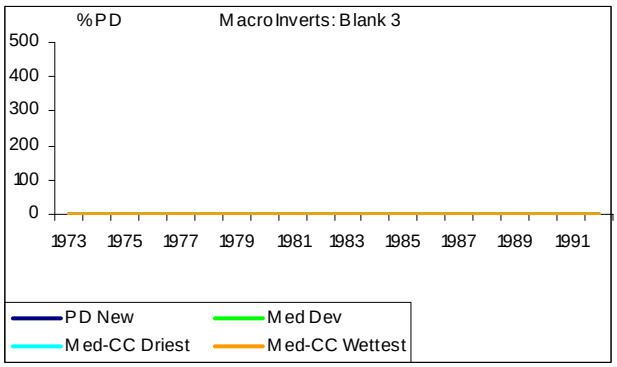
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

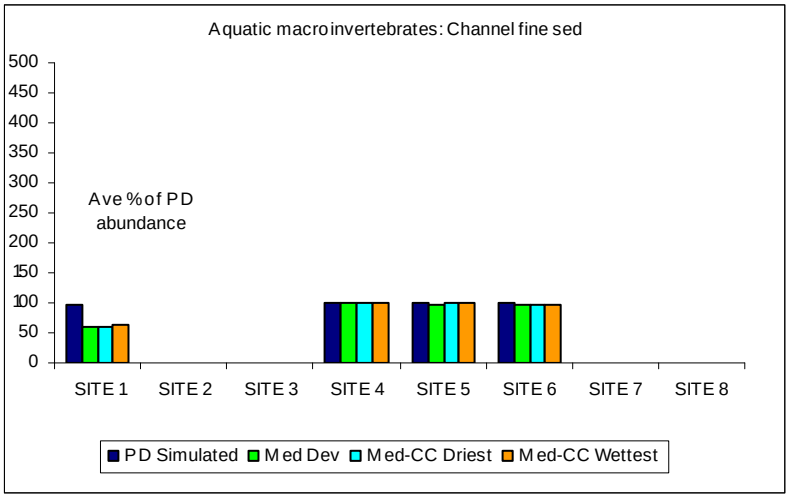


Site 8: Boteti River



Summary change per scenario

Will normally survive as long as there is some water covering the sediment. Long dry spells will reduce abundance or even eliminate these indicators.



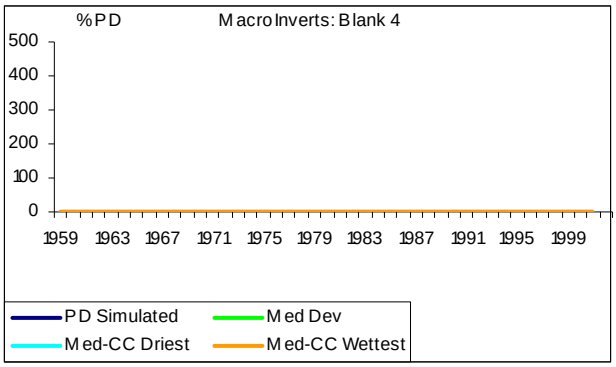
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

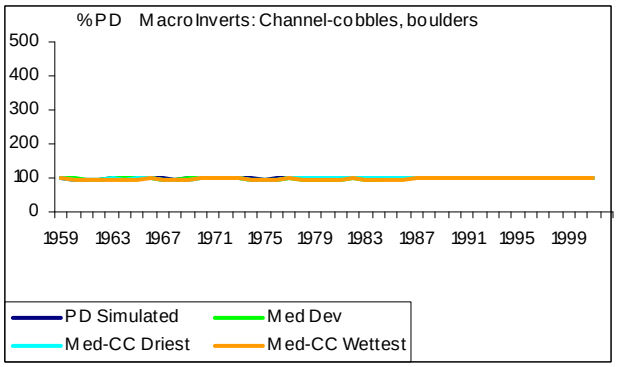
4.4.4 Channel-cobbles, boulders

(Channel dwellers in stones and rocks)- Hydropsychidae, Ecnomidae

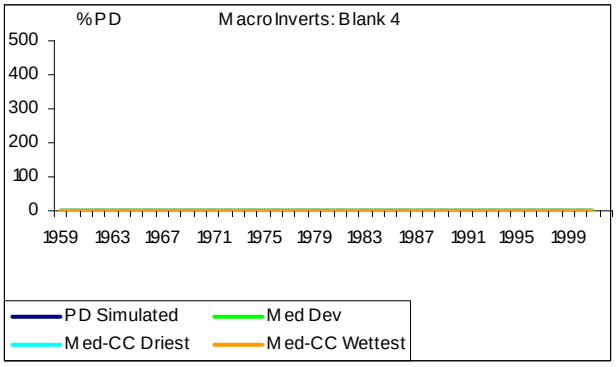
Site 1: Cubango River @ Capico



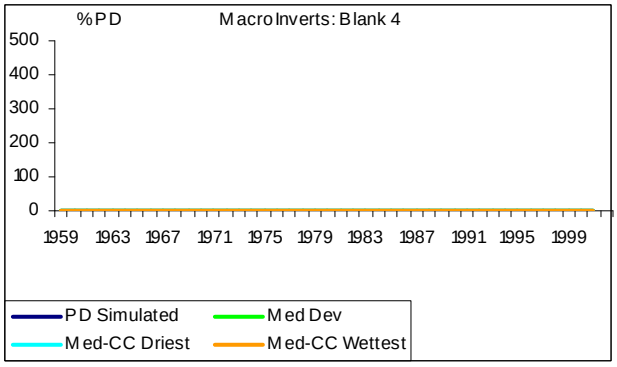
Site 2: Cubango River @ Mucundi



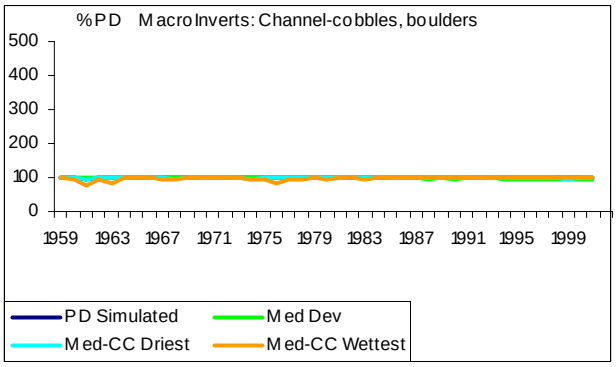
Site 3: Cuito River @ Cuito Cuanavale



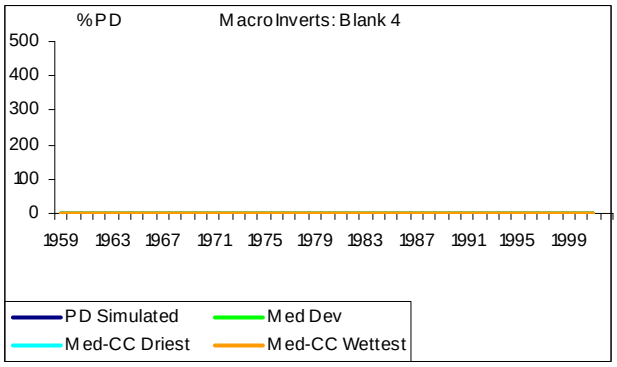
Site 4: Okavango River @ Rundu



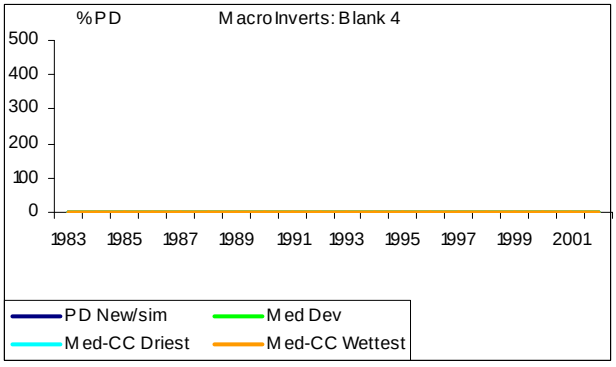
Site 5: Okavango River @ Popa Falls



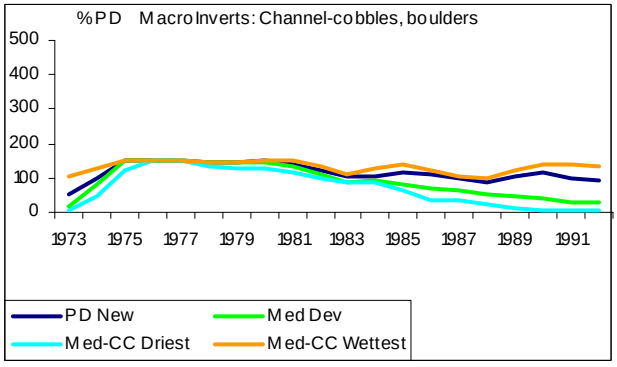
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

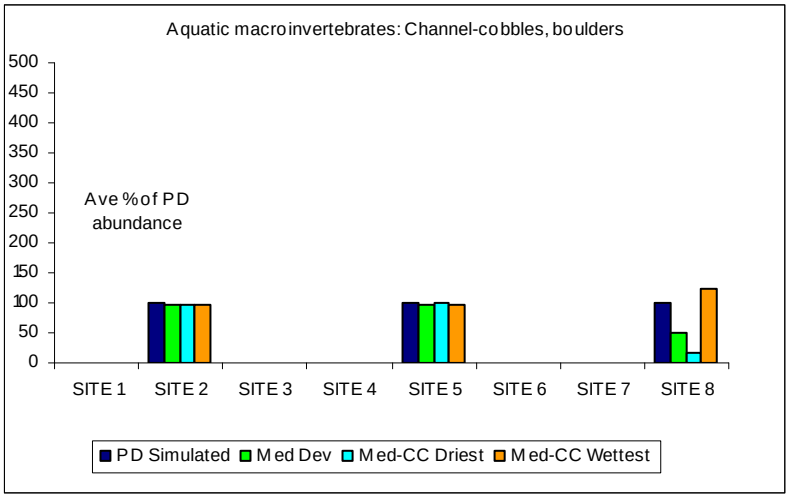


Site 8: Boteti River



Summary change per scenario

Water must always be present. These indicators will reduce and may disappear if exposed to long duration of minimum flows leading to drying of rocks.



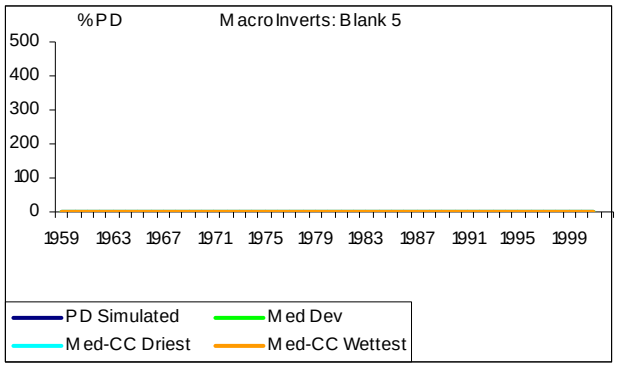
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

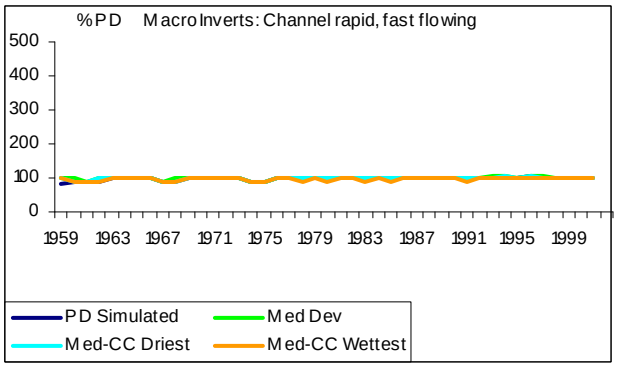
4.4.5 Channel rapid, fast flowing

(Channel dwellers in rapids or fast flowing waters)- Simuliidae, Hydropsychidae

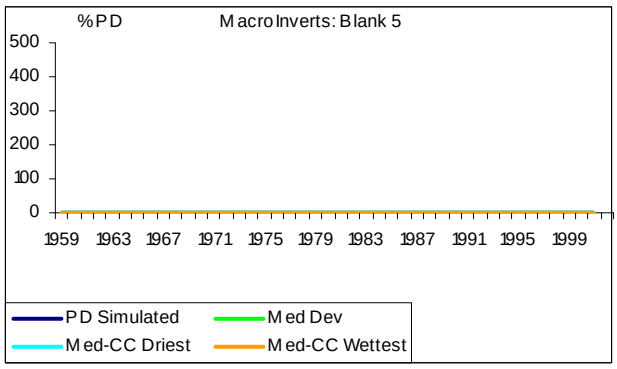
Site 1: Cubango River @ Capico



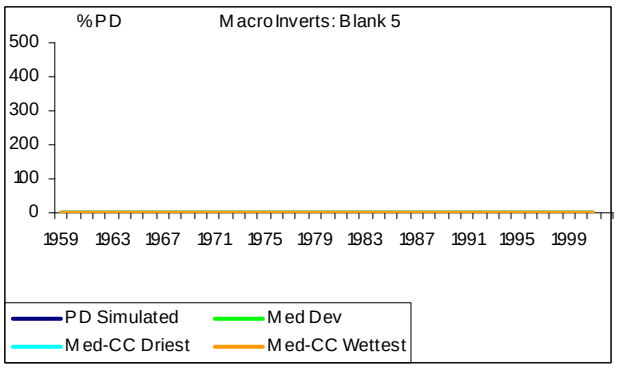
Site 2: Cubango River @ Mucundi



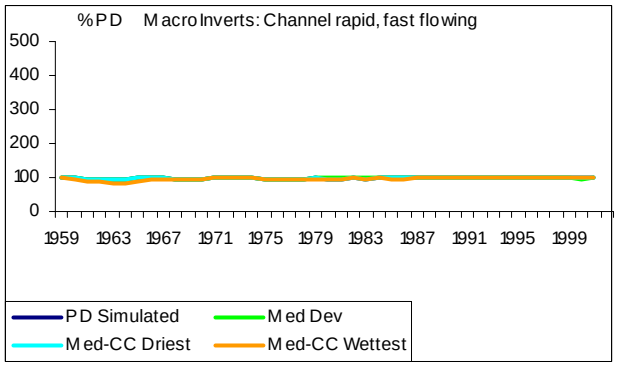
Site 3: Cuito River @ Cuito Cuanavale



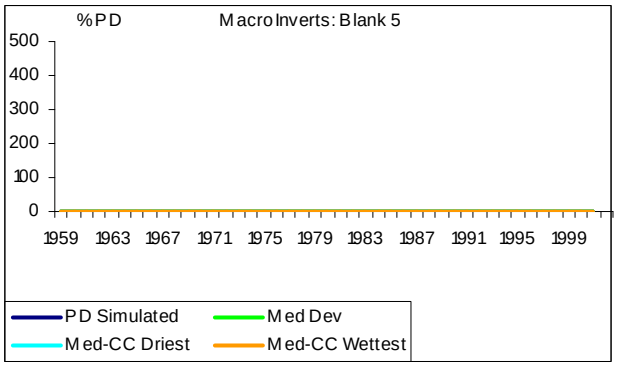
Site 4: Okavango River @ Rundu



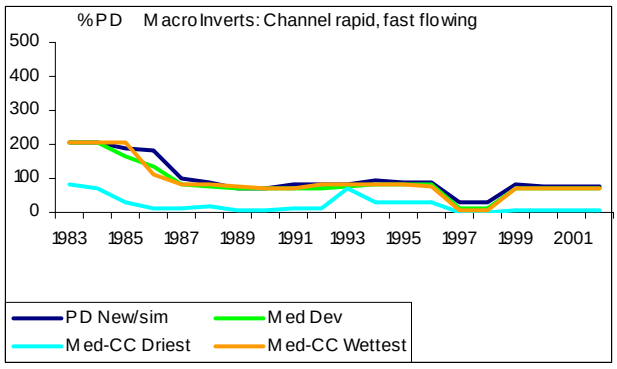
Site 5: Okavango River @ Popa Falls



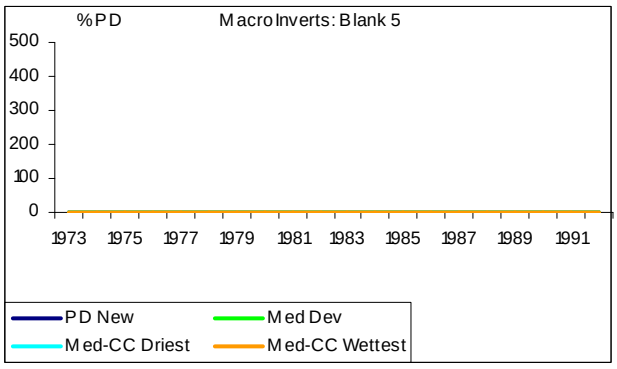
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

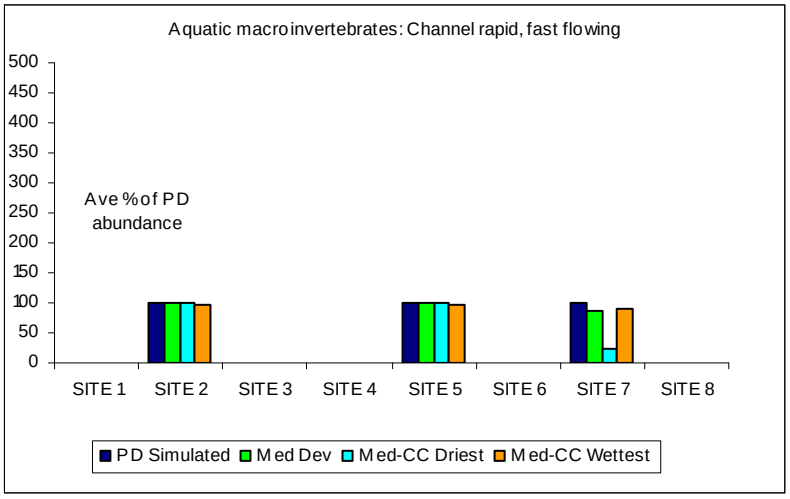


Site 8: Boteti River



Summary change per scenario

Water must always be present. These indicators will reduce and may disappear if exposed to long duration of minimum flows leading to drying of river bed.



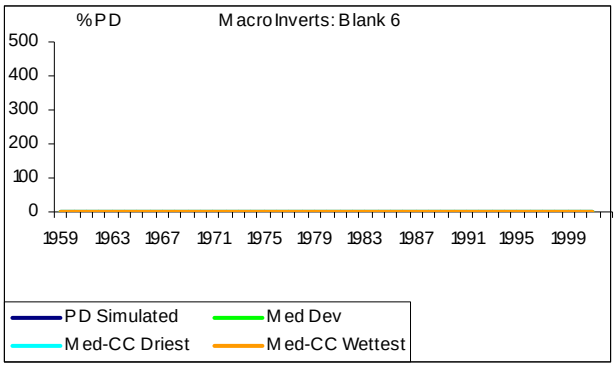
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

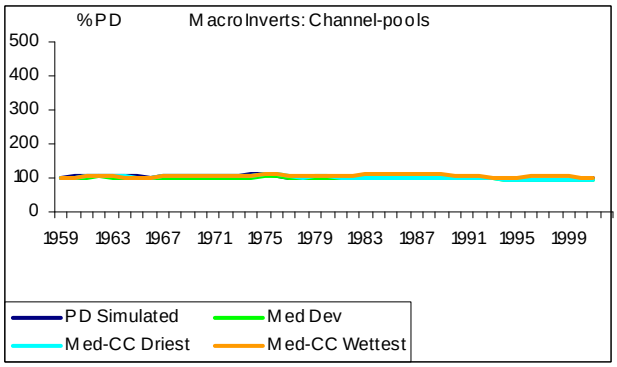
4.4.6 Channel-pools

(hollows formed in the bedrock)- Dytiscidae

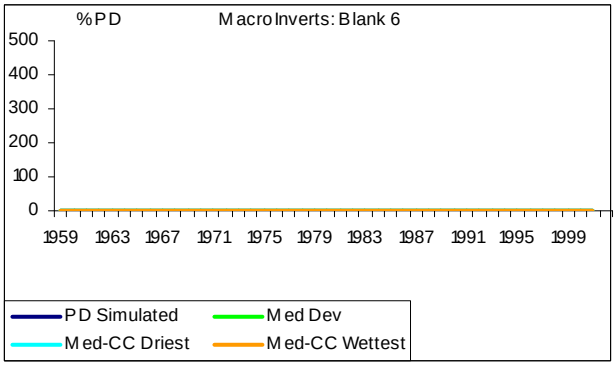
Site 1: Cubango River @ Capico



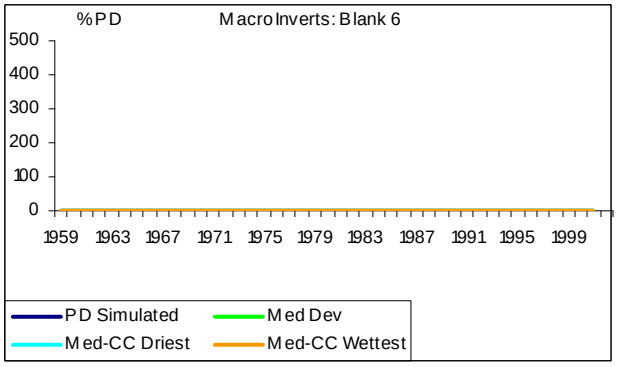
Site 2: Cubango River @ Mucundi



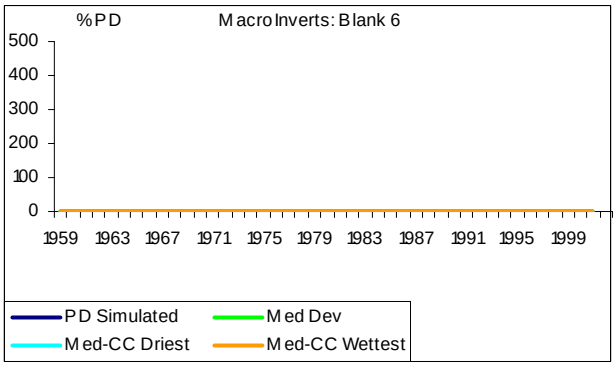
Site 3: Cuito River @ Cuito Cuanavale



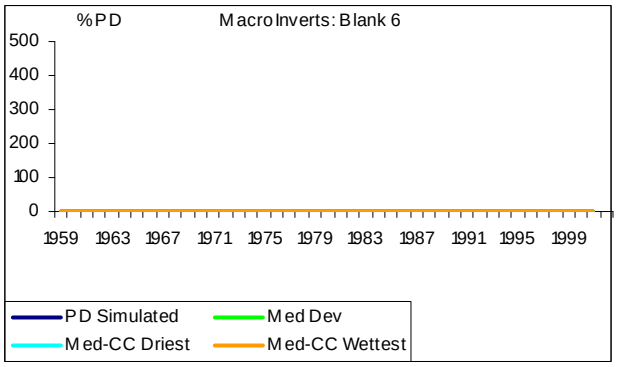
Site 4: Okavango River @ Rundu



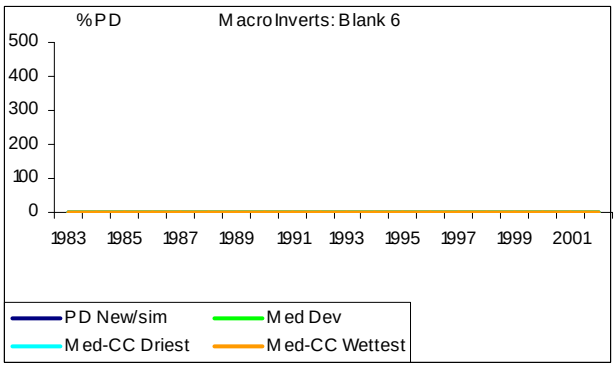
Site 5: Okavango River @ Popa Falls



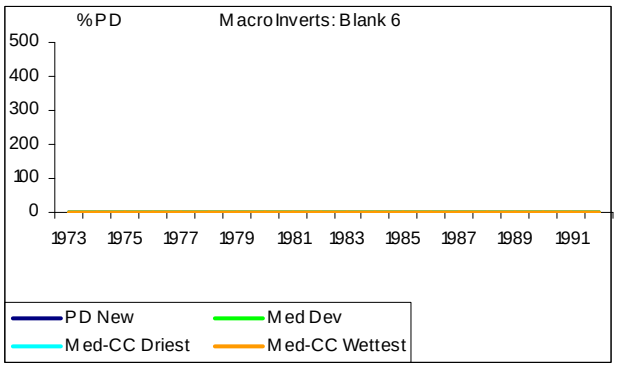
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

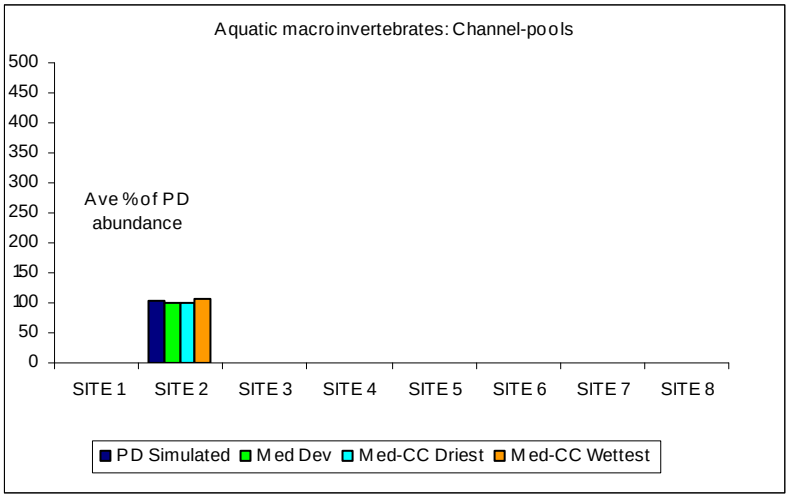


Site 8: Boteti River



Summary change per scenario

Water must always be present. High, long-duration flooding will destroy this habitat while long duration of minimum flows may lead to drying out of the pools also destroying the pools.



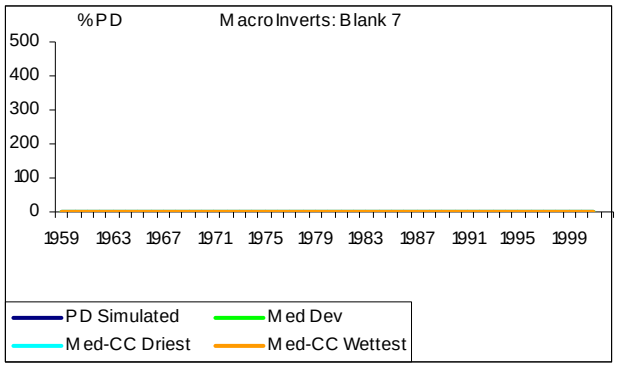
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

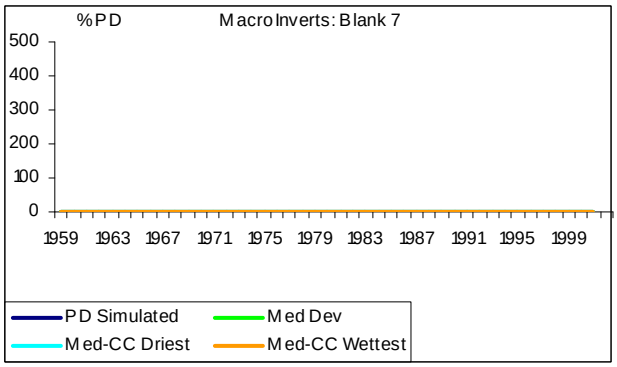
4.4.7 Floodplain marginal vegetation

(Floodplain dwellers in marginal vegetation)- Coenagrionidae, Physidae, Planorbidae

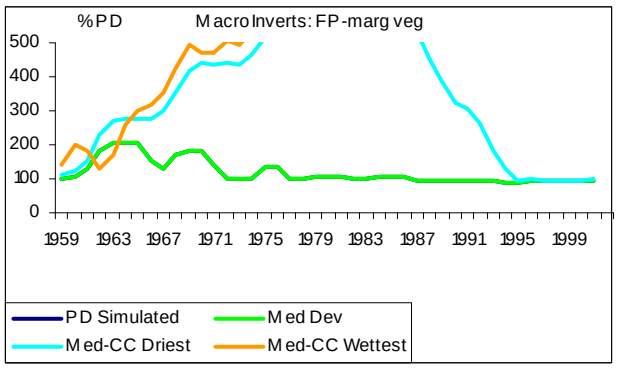
Site 1: Cubango River @ Capico



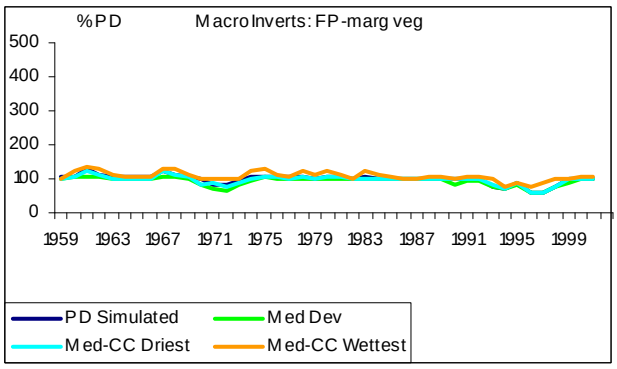
Site 2: Cubango River @ Mucundi



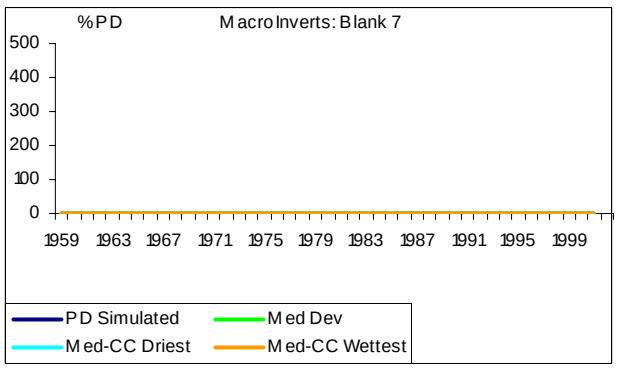
Site 3: Cuito River @ Cuito Cuanavale



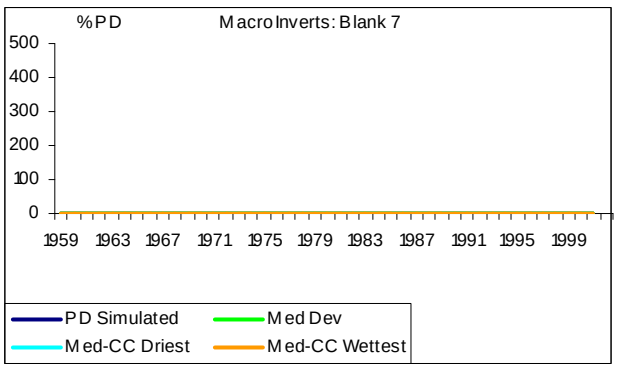
Site 4: Okavango River @ Rundu



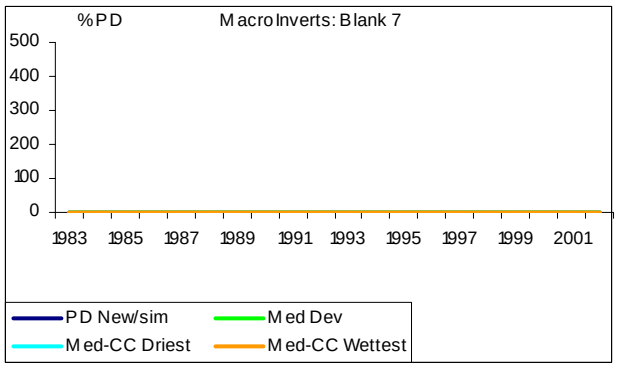
Site 5: Okavango River @ Popa Falls



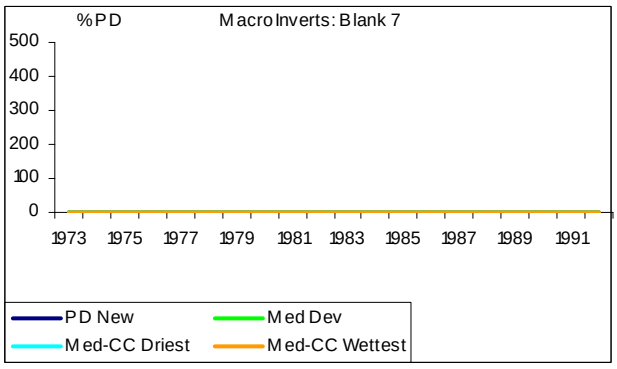
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

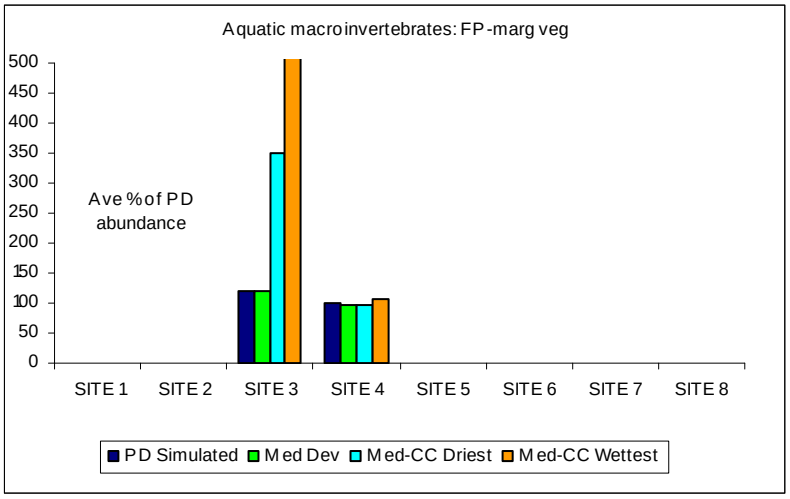


Site 8: Boteti River



Summary change per scenario

Drying out of floodplains consequent to prolonged low flows will reduce or eradicate this habitat.



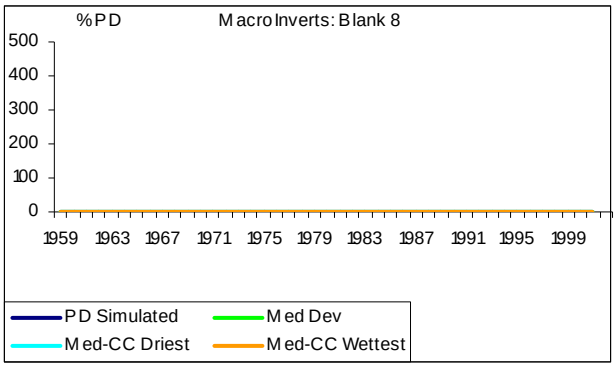
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

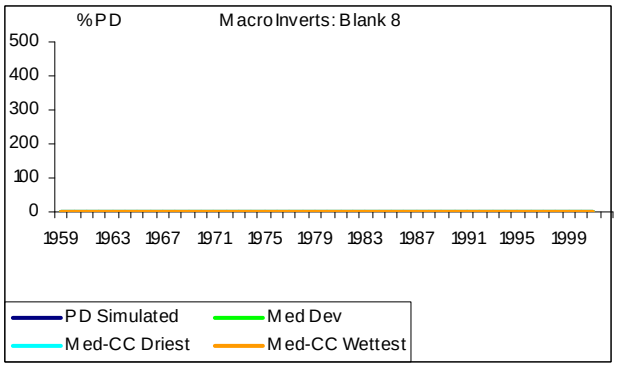
4.4.8 Floodplain pools, backwaters

(Dwellers in seasonal floodplain backwaters)- Dytiscidae

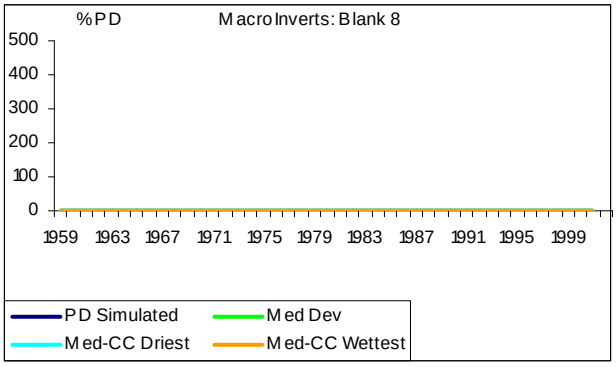
Site 1: Cubango River @ Capico



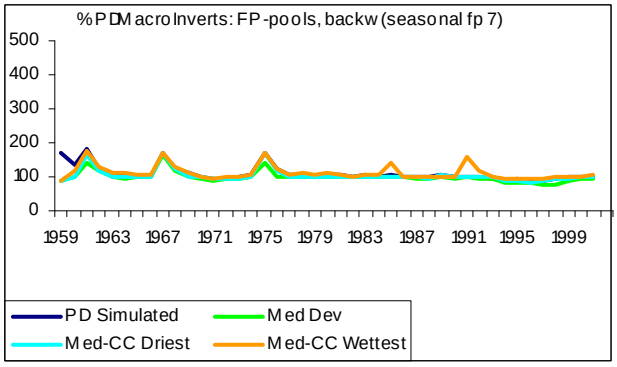
Site 2: Cubango River @ Mucundi



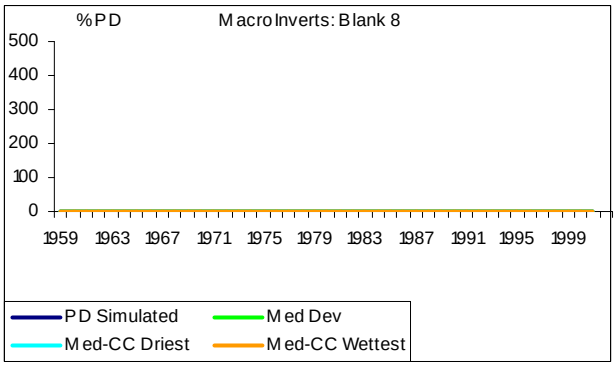
Site 3: Cuito River @ Cuito Cuanavale



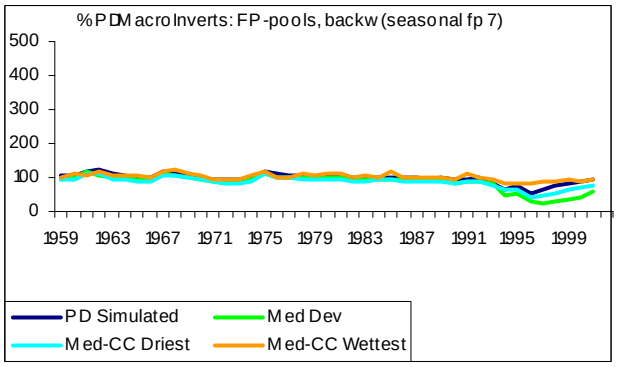
Site 4: Okavango River @ Rundu



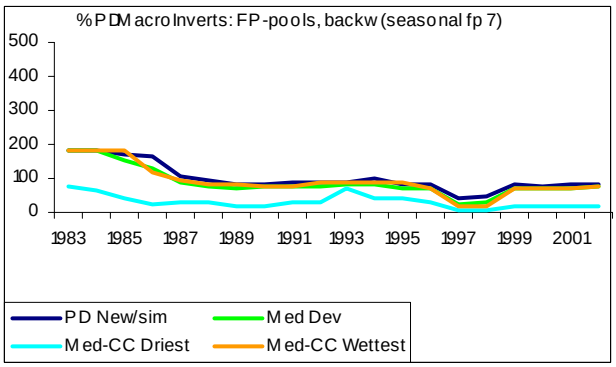
Site 5: Okavango River @ Popa Falls



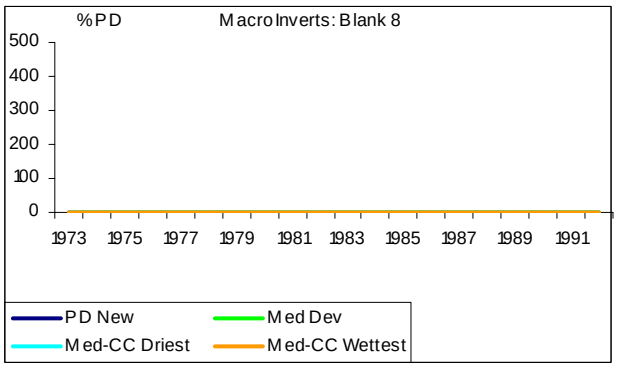
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

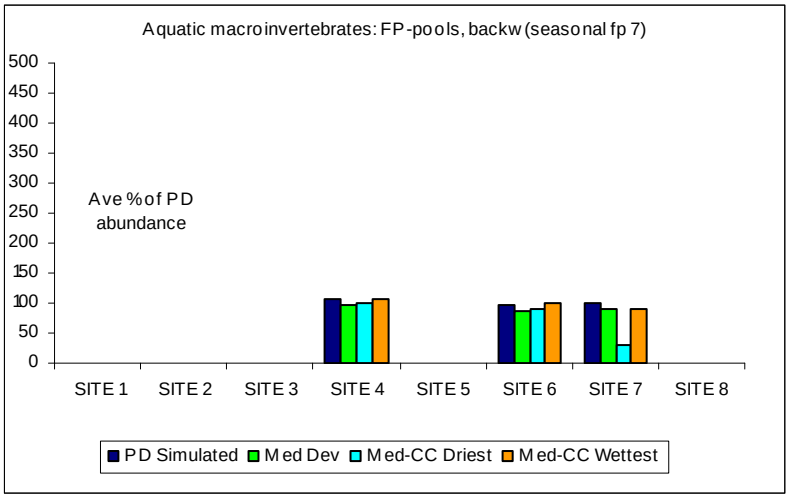


Site 8: Boteti River



Summary change per scenario

Drying out of floodplains consequent to prolonged low flows will reduce or eradicate this habitat.



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.5. Fish

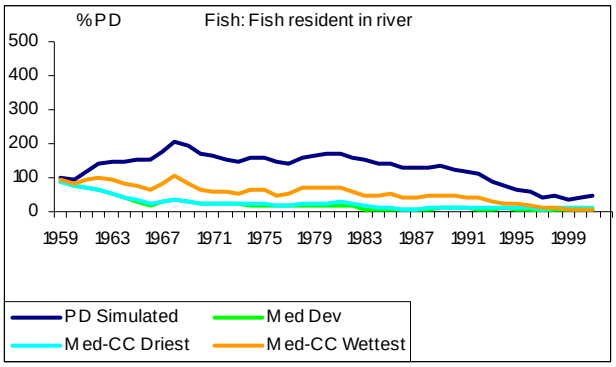
This section provides the time-series for fish indicators under the flow regime resulting from the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Fish resident in river
- Migrate floodplain small fish
- Migrate floodplain large fish
- Fish-sandbank dweller
- Fish-rock dweller
- Fish-marginal vegetation
- Fish in backwaters.

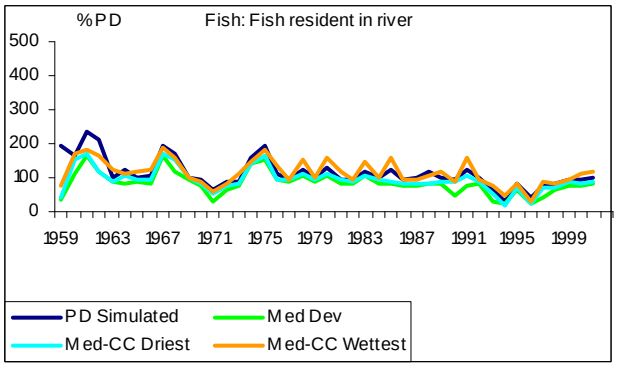
4.5.1 Fish resident in river

(Living in main channels, undertake longitudinal migrations.)- Spend most time in main channel in deep water but use floodplain. Example Tigerfish [Hydrocynus vittatus].

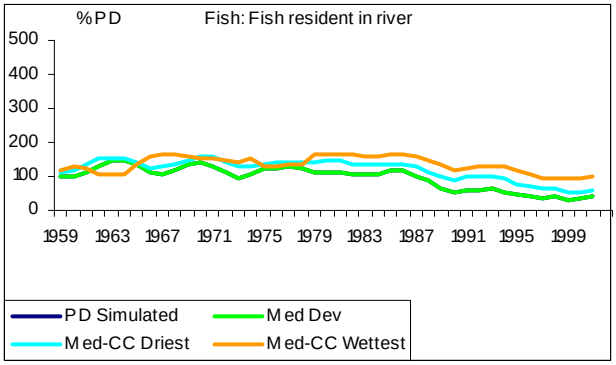
Site 1: Cubango River @ Capico



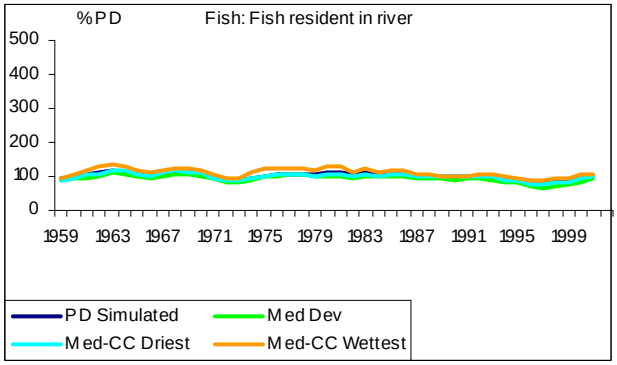
Site 2: Cubango River @ Mucundi



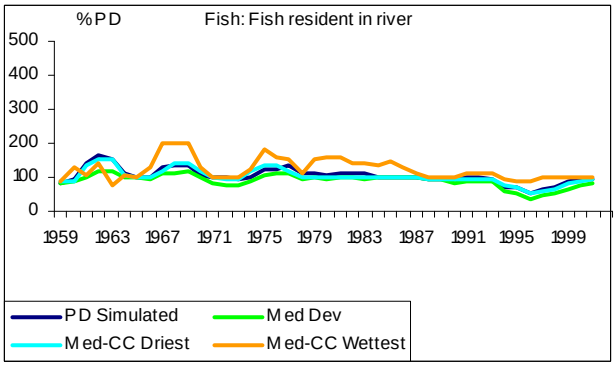
Site 3: Cuito River @ Cuito Cuanavale



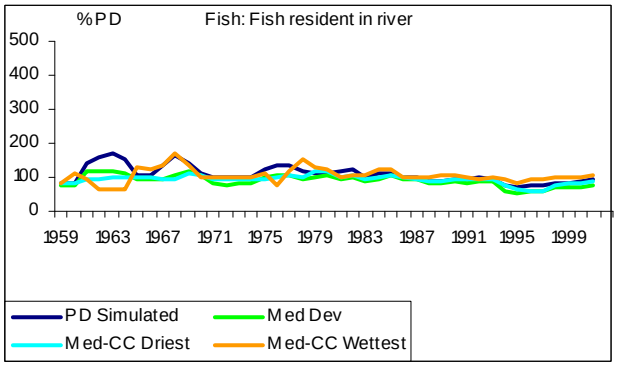
Site 4: Okavango River @ Rundu



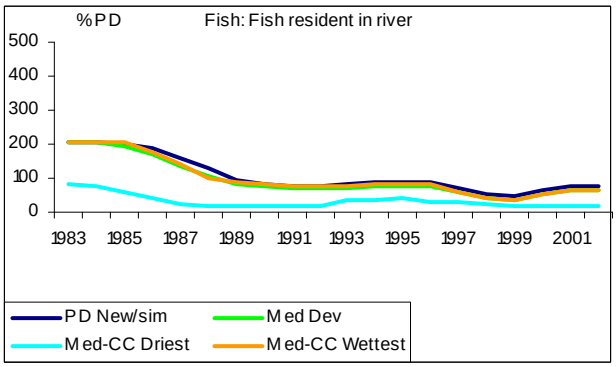
Site 5: Okavango River @ Popa Falls



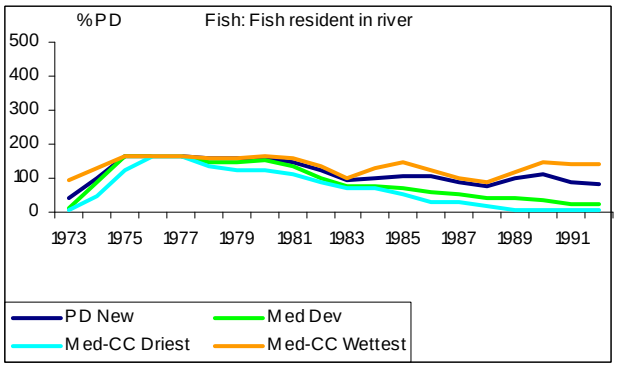
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

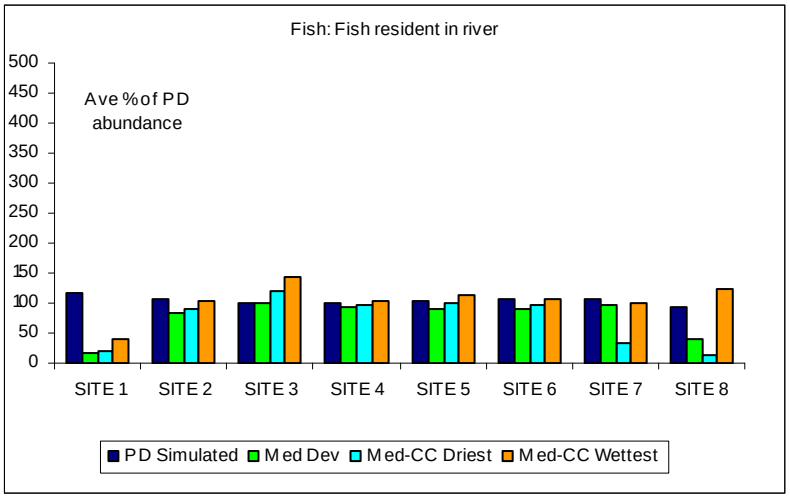


Site 8: Boteti River



Summary change per scenario

Require clear deep, running water and pools throughout the hydrological cycle.



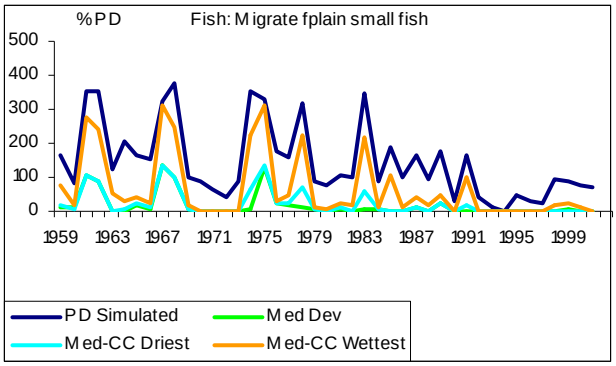
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

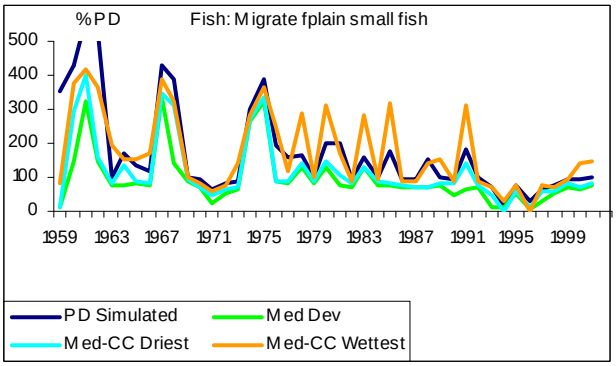
4.5.2 Migrate floodplain - small fish

(Resident in river, migrate into floodplains for feeding, breeding and protection against predation.)- Small species dependent on lateral migration to floodplains for breeding and feeding. Example Bulldog [Marcusenius macrolepidotus].

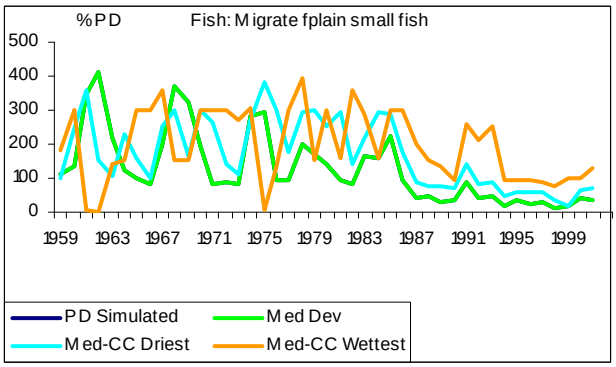
Site 1: Cubango River @ Capico



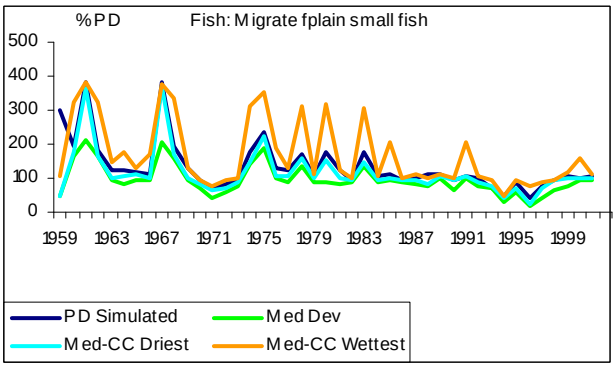
Site 2: Cubango River @ Mucundi



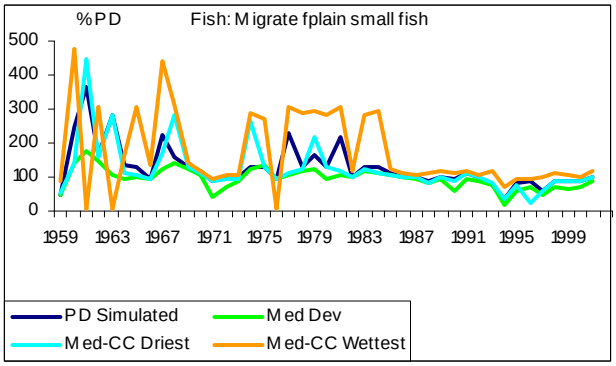
Site 3: Cuito River @ Cuito Cuanavale



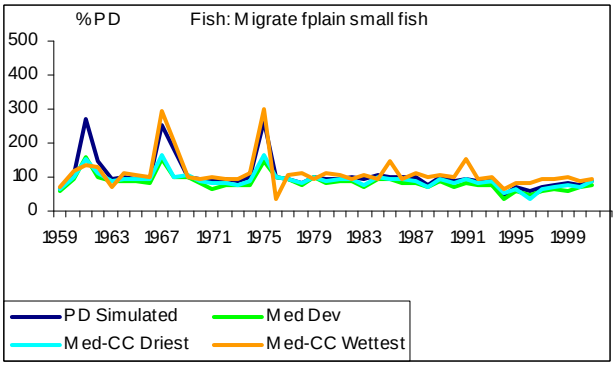
Site 4: Okavango River @ Rundu



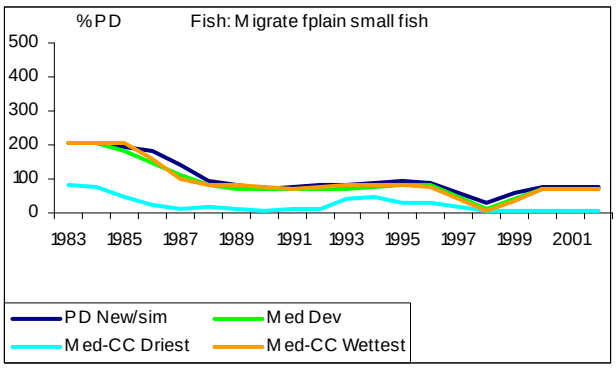
Site 5: Okavango River @ Popa Falls



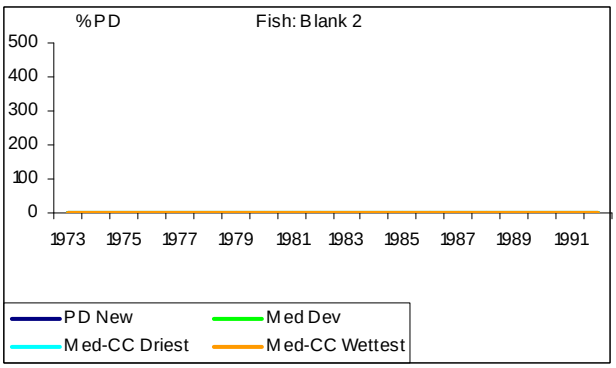
Site 6: Okavango River @ Pan Handle



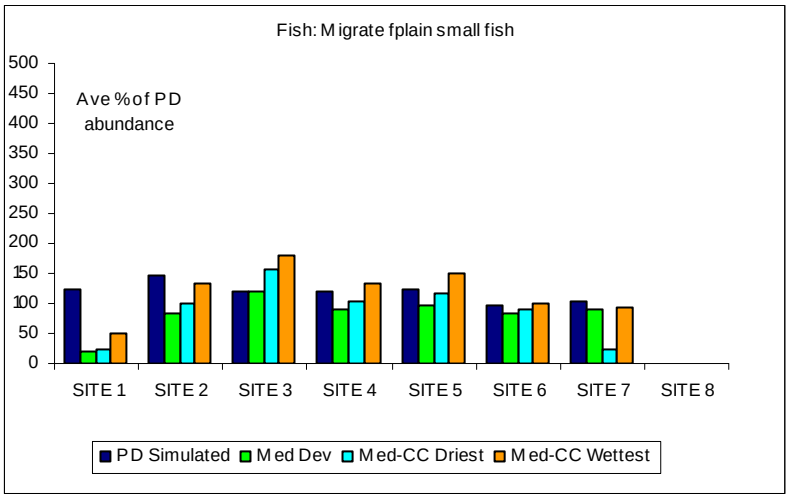
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Depend on regular flooding of shallow vegetated floodplains and deeper [>50cm] refuges during low flow conditions.

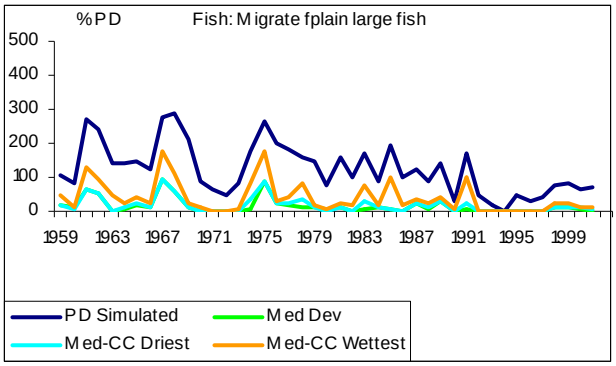


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

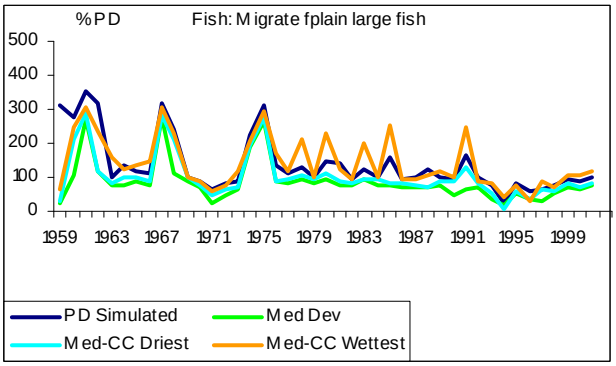
4.5.3 Migrate floodplain - large fish

(Resident in river, migrate into floodplains for feeding, breeding and protection against predation.)- Large species dependent on lateral migration to floodplains for breeding and feeding. Example Redbreast tilapia [Tilapia rendalli].

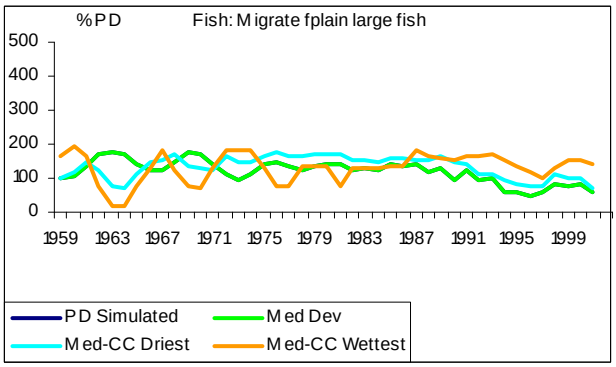
Site 1: Cubango River @ Capico



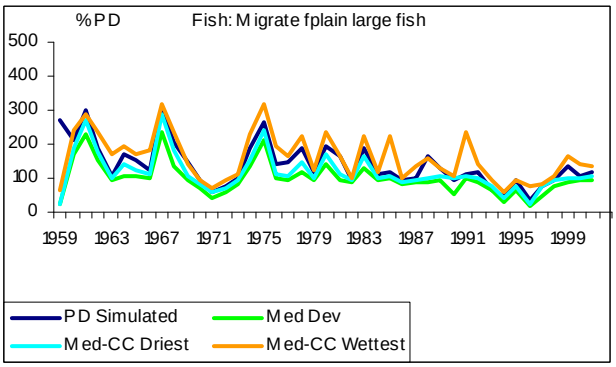
Site 2: Cubango River @ Mucundi



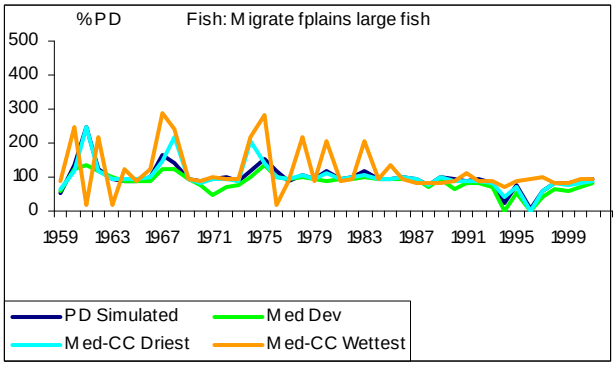
Site 3: Cuito River @ Cuito Cuanavale



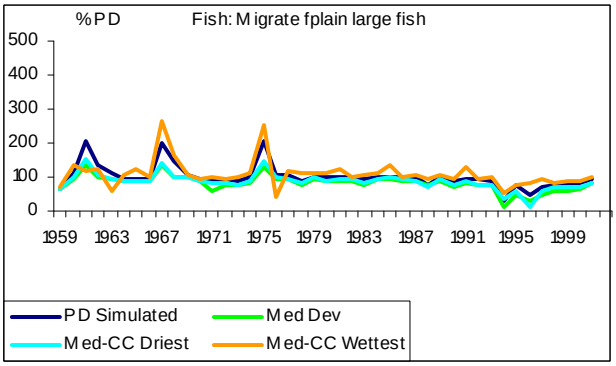
Site 4: Okavango River @ Rundu



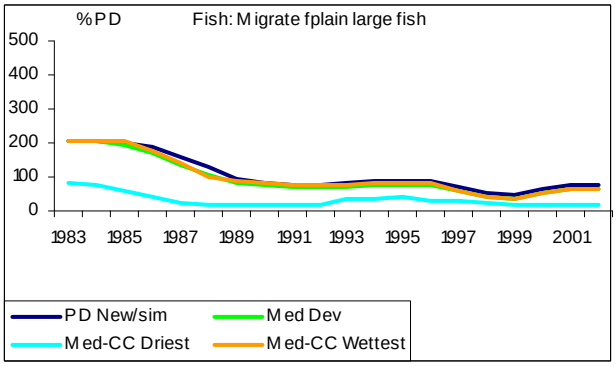
Site 5: Okavango River @ Popa Falls



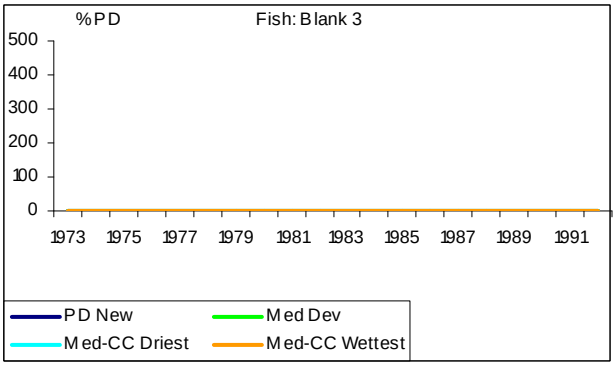
Site 6: Okavango River @ Pan Handle



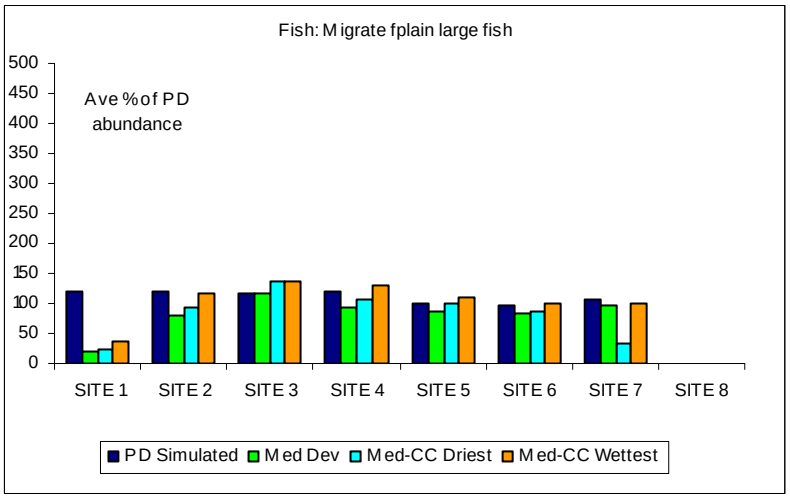
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Depend on regular flooding of shallow vegetated floodplains and deeper [>200cm] refuges during low flow conditions.

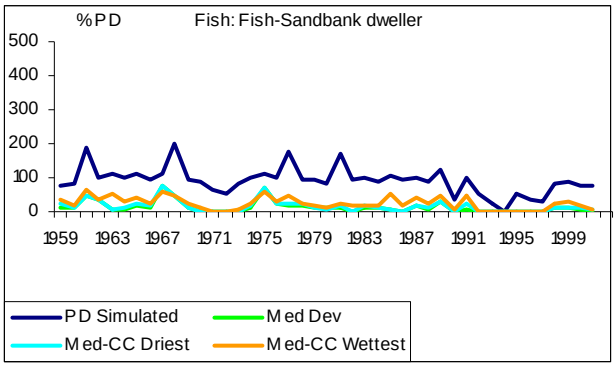


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

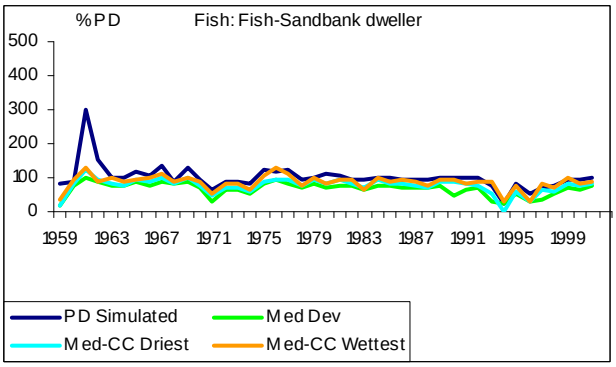
4.5.4 Fish-Sandbank dweller

(Species living on sandbanks and habitats with sandy bottoms.)- Fish species living mainly on the actively moving sandbanks or a sandy bottom. Example Sand catlet [Leptoglanis cf dorae].

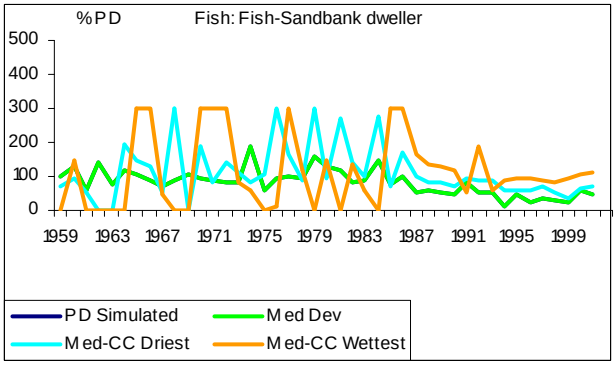
Site 1: Cubango River @ Capico



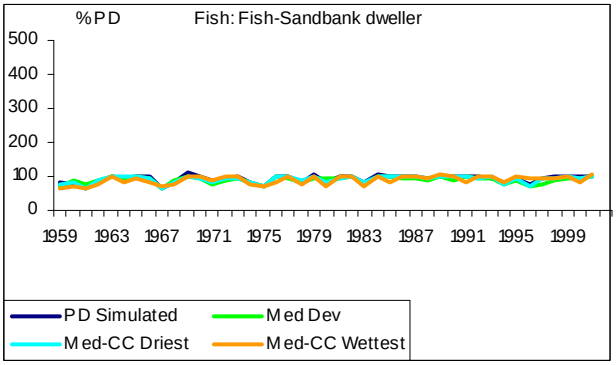
Site 2: Cubango River @ Mucundi



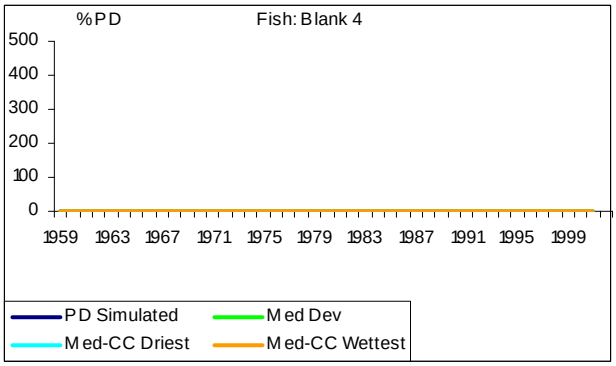
Site 3: Cuito River @ Cuito Cuanavale



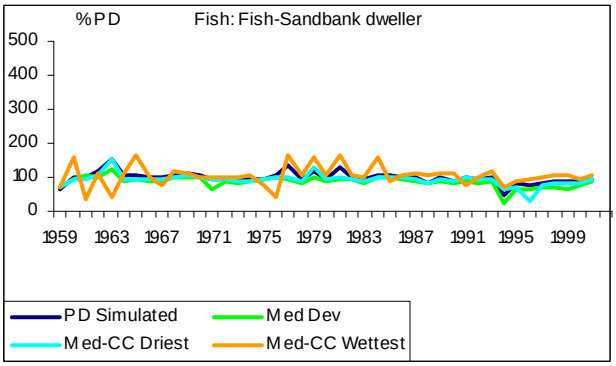
Site 4: Okavango River @ Rundu



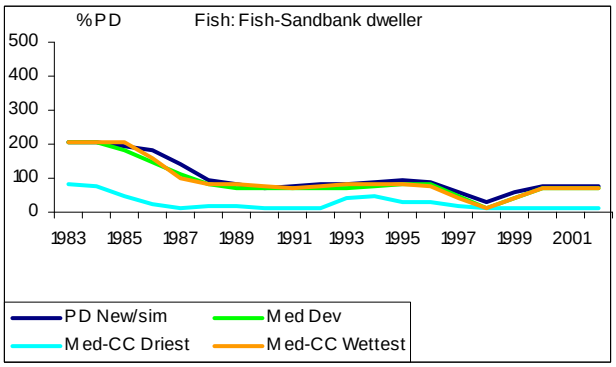
Site 5: Okavango River @ Popa Falls



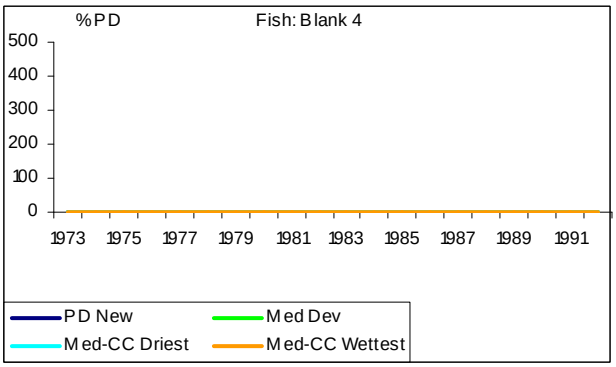
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

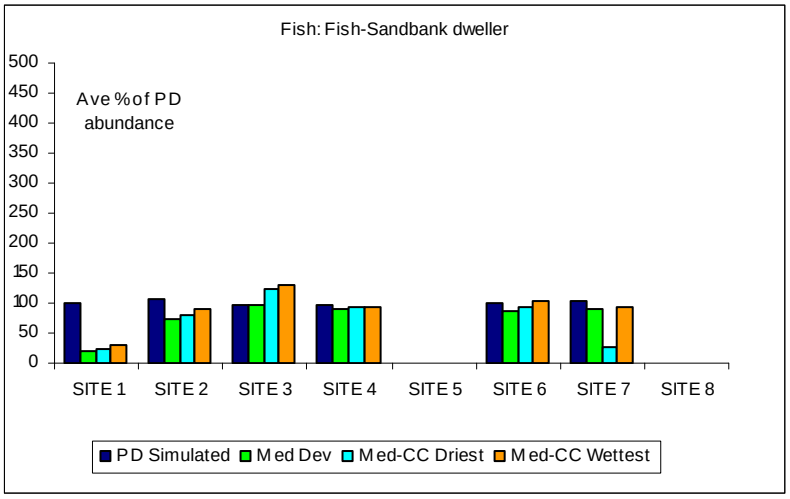


Site 8: Boteti River



Summary change per scenario

Depend on active sandbanks with flowing water and seasonal natural variation of water levels.



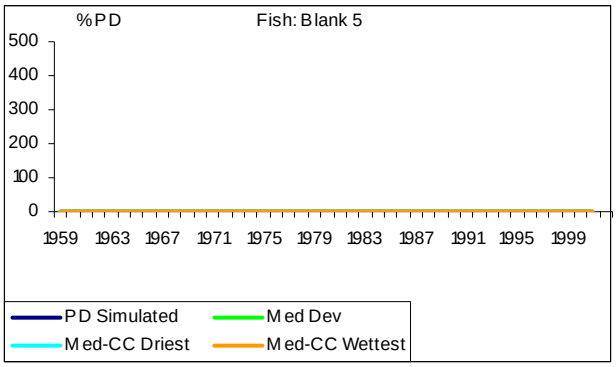
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

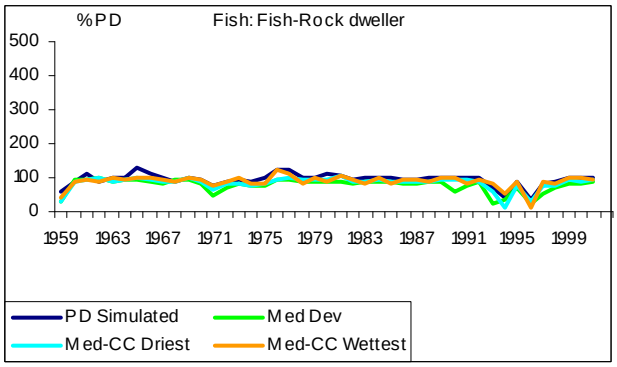
4.5.5 Fish-Rock dweller

(Rheophillic species of riffles and rapids) - Fish species living amongst rocks and in crevices in flowing water. Example Southern stargazer [Amphilius uranoscopus].

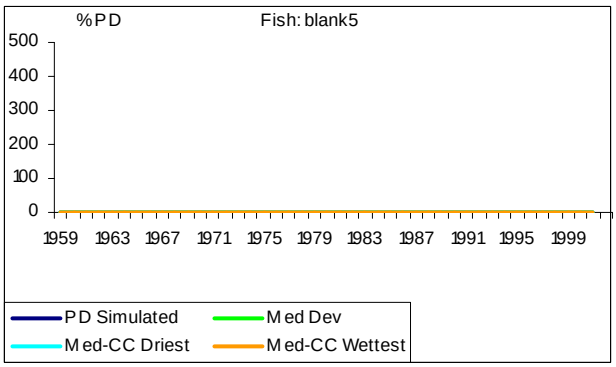
Site 1: Cubango River @ Capico



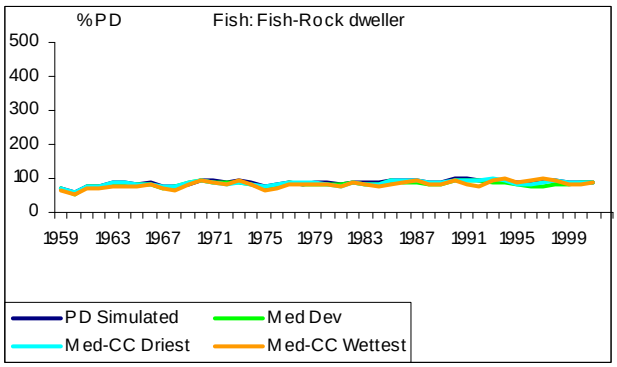
Site 2: Cubango River @ Mucundi



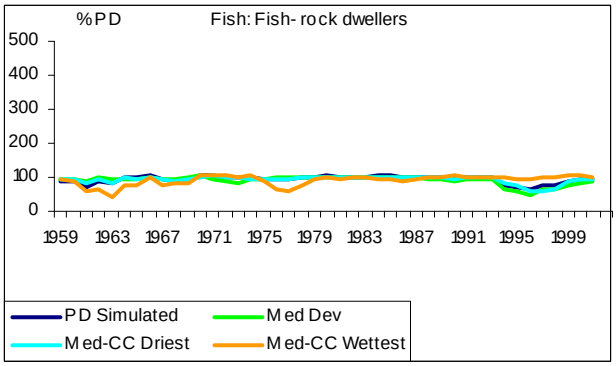
Site 3: Cuito River @ Cuito Cuanavale



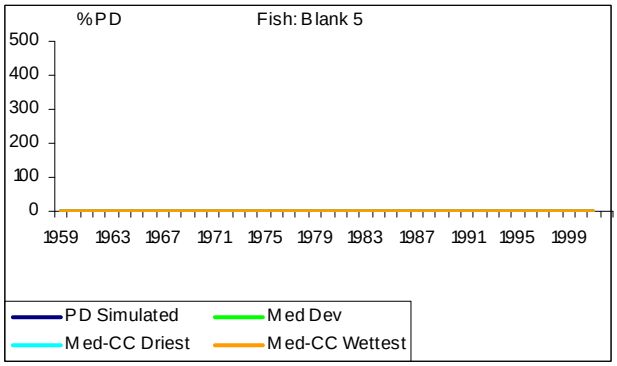
Site 4: Okavango River @ Rundu



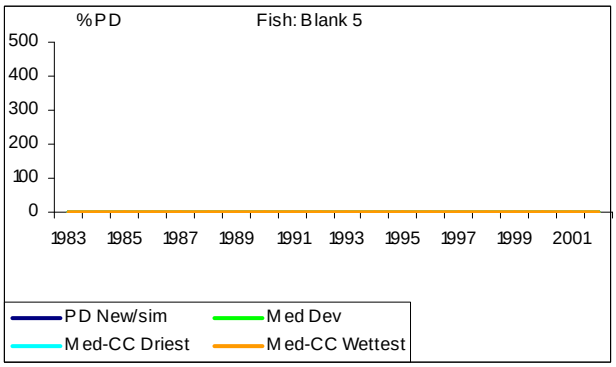
Site 5: Okavango River @ Popa Falls



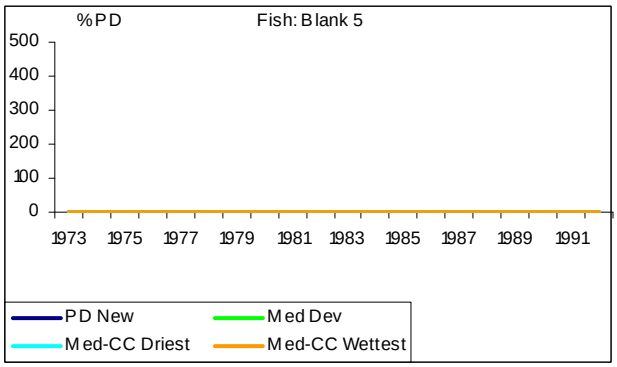
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

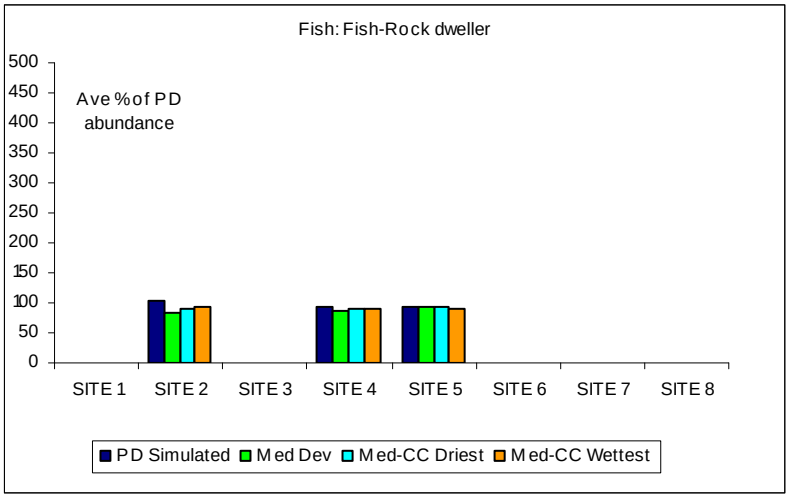


Site 8: Boteti River



Summary change per scenario

Depend on presence of a rocky bottom and flowing water as well as natural variation in water level.



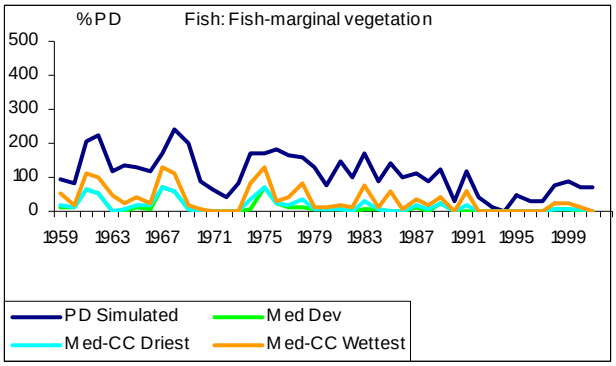
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

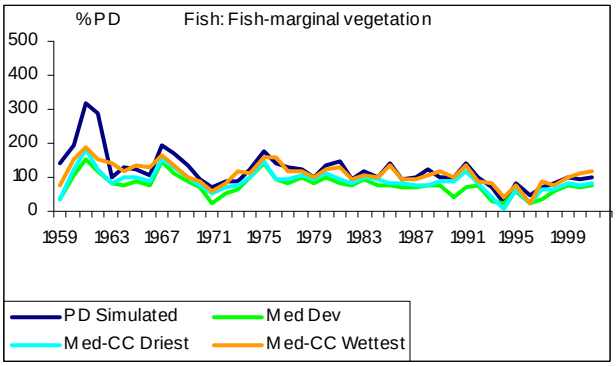
4.5.6 Fish-marginal vegetation

(Species living amongst marginal vegetation on edge of channels.)- Fish species living mainly amongst vegetation on margin of river and may move into floodplains during flood conditions. Example Banded tilapia [Tilapia sparrmanii].

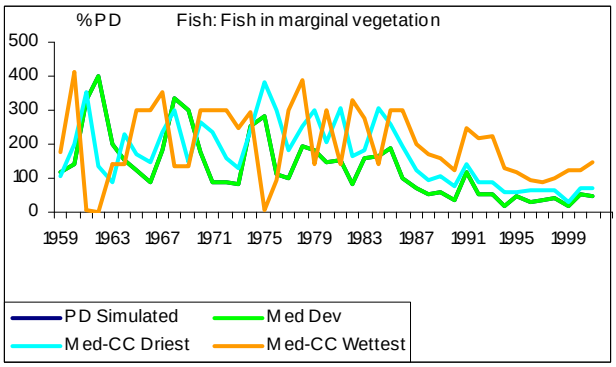
Site 1: Cubango River @ Capico



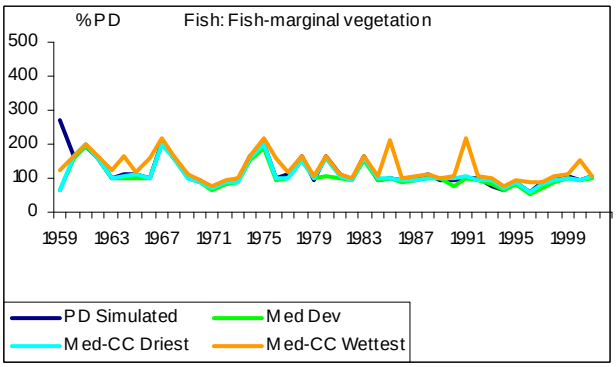
Site 2: Cubango River @ Mucundi



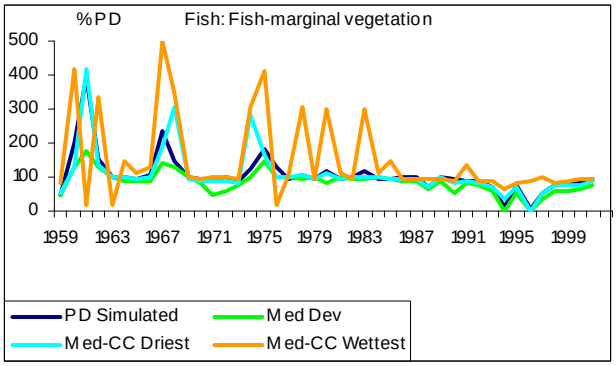
Site 3: Cuito River @ Cuito Cuanavale



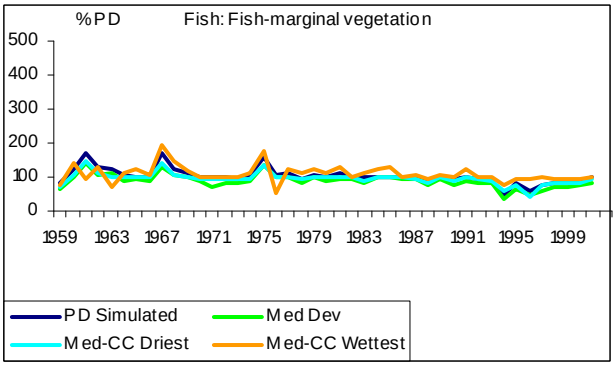
Site 4: Okavango River @ Rundu



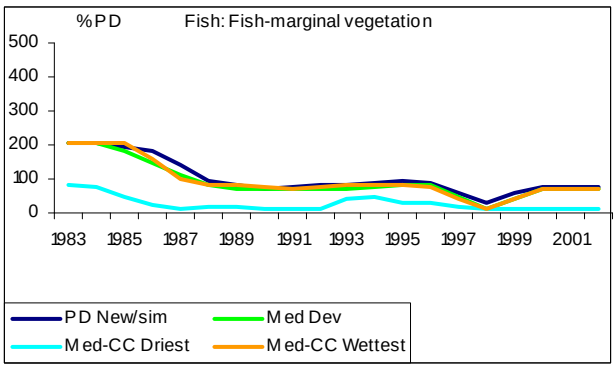
Site 5: Okavango River @ Popa Falls



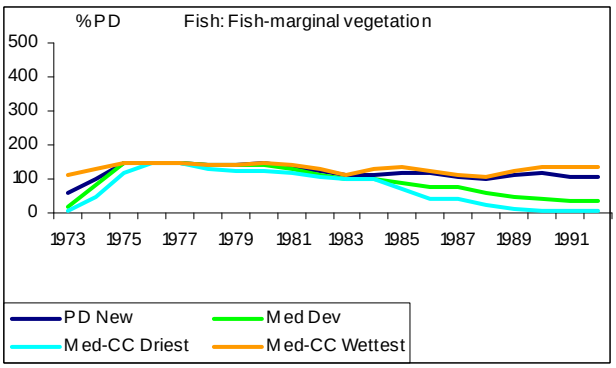
Site 6: Okavango River @ Pan Handle



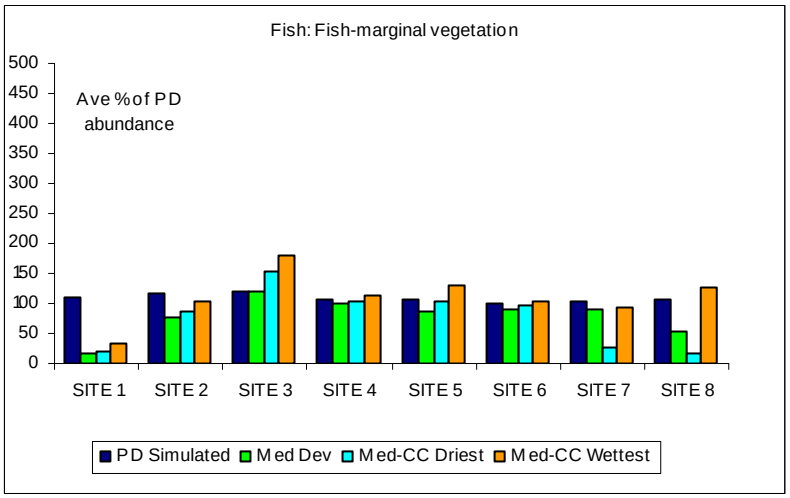
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Depend on the presence of marginal vegetation, stable soils and naturally varying water levels for establishment of emergent and submerged vegetation.

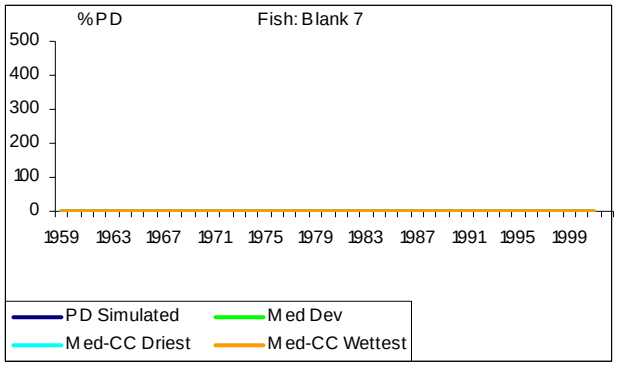


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

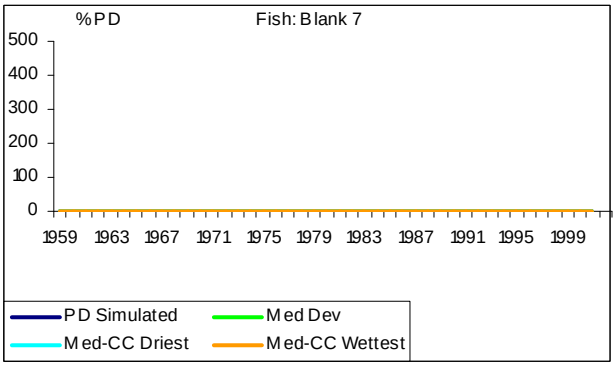
4.5.7 Fish in backwaters

(Fish species living in vegetated pools and backwaters.)- Fish species living mainly amongst vegetation on margin of river and associated backwaters during low water level conditions. May move into floodplains during flood conditions. Example Okavango tilapia [Tilapia ruweti].

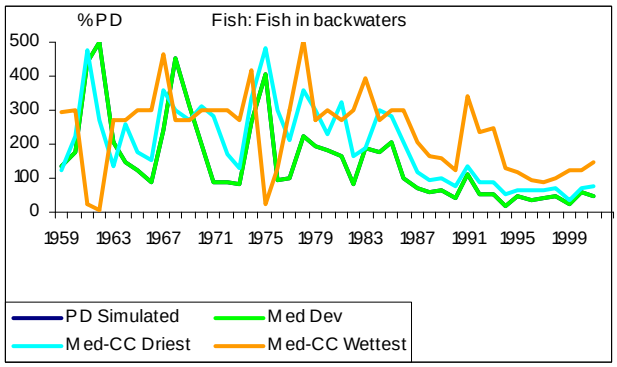
Site 1: Cubango River @ Capico



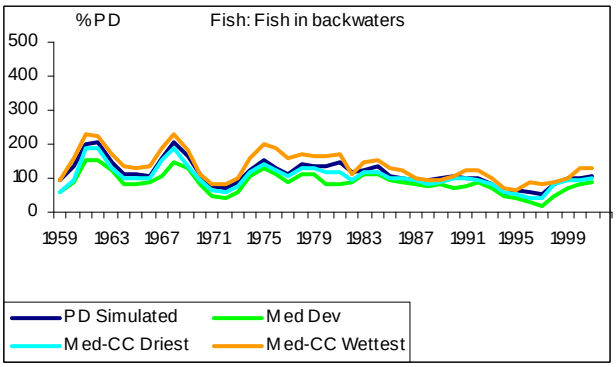
Site 2: Cubango River @ Mucundi



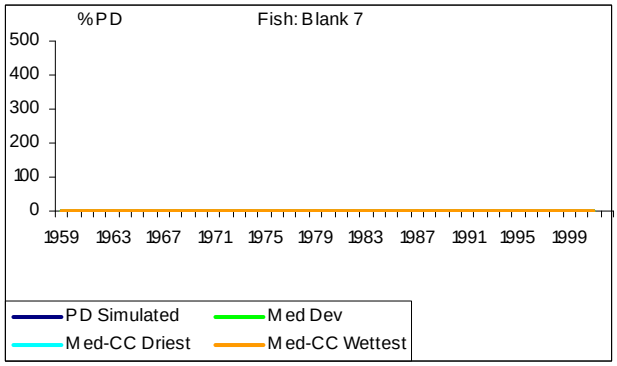
Site 3: Cuito River @ Cuito Cuanavale



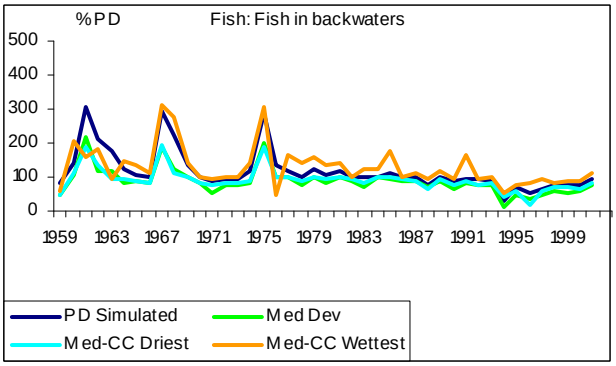
Site 4: Okavango River @ Rundu



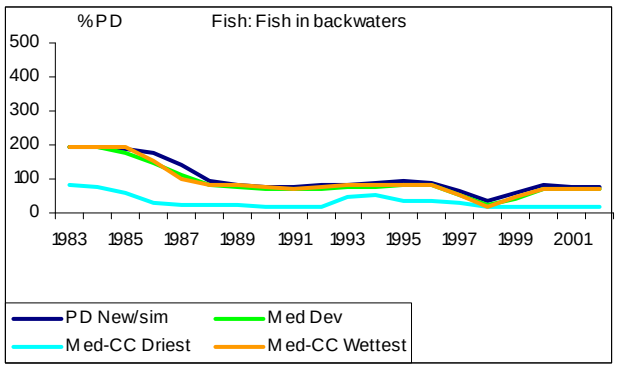
Site 5: Okavango River @ Popa Falls



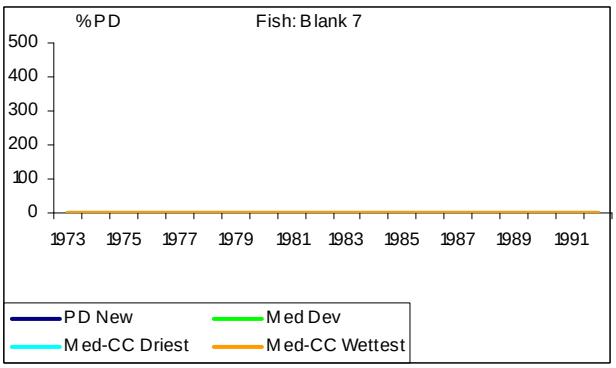
Site 6: Okavango River @ Pan Handle



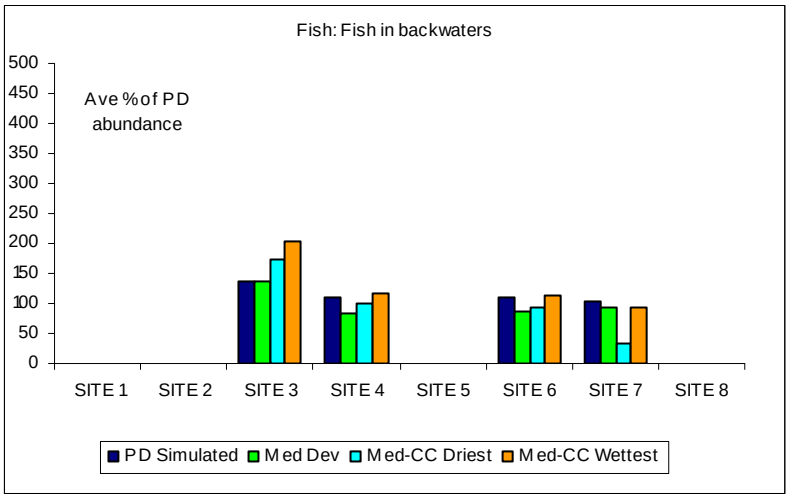
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Depend on maintenance of oxbows and pools on the margin of the floodplain of the river by normal natural hydrological regime, including standing water conditions during low flow.



References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.6. Wildlife

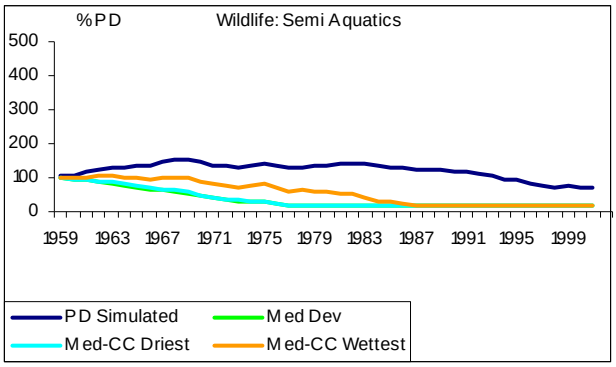
This section provides the time-series for the wildlife indicators under the flow regime resulting from the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Semi Aquatics (hippos, crocodiles)
- Frogs, river snakes
- Lower floodplain grazers
- Middle floodplain grazers
- Outer floodplain grazers.

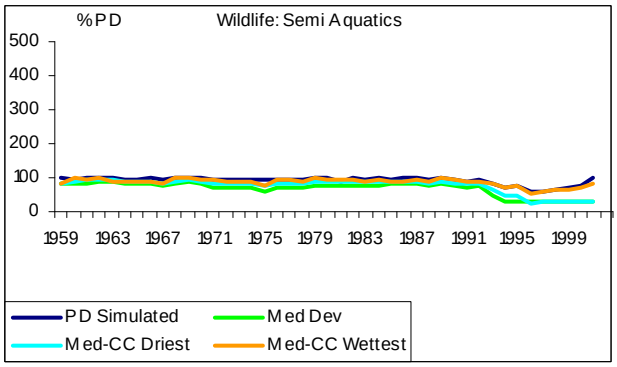
4.6.1 Semi aquatics

(Main channel dwellers, but ranging over banks, floodplains and Islands)- Hippopotamus, crocodile, otters, monitors and terrapins

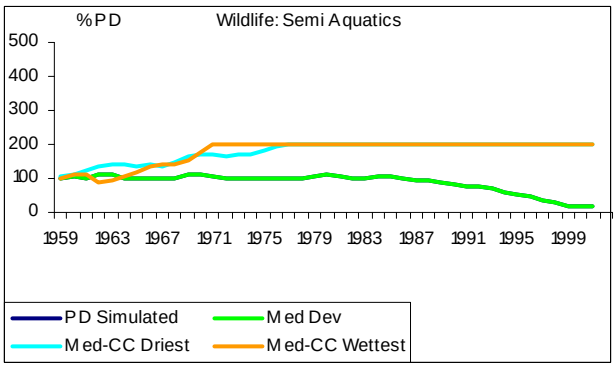
Site 1: Cubango River @ Capico



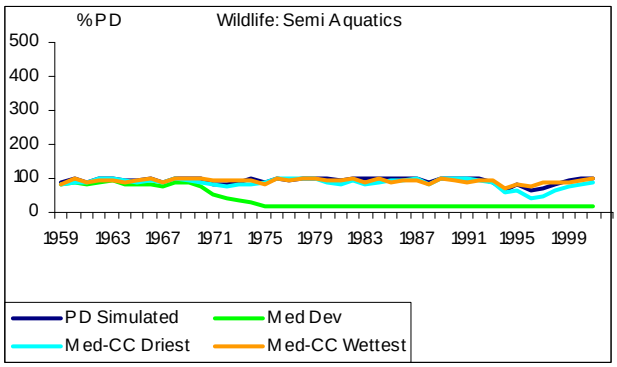
Site 2: Cubango River @ Mucundi



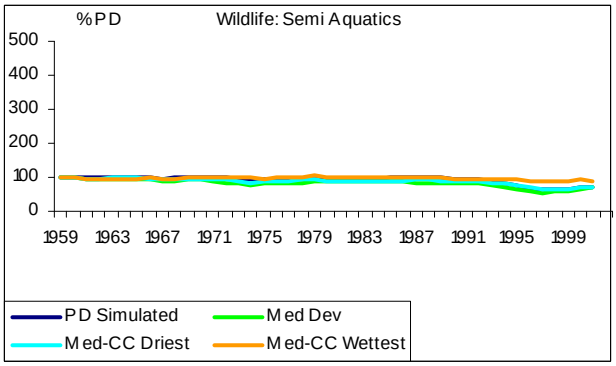
Site 3: Cuito River @ Cuito Cuanavale



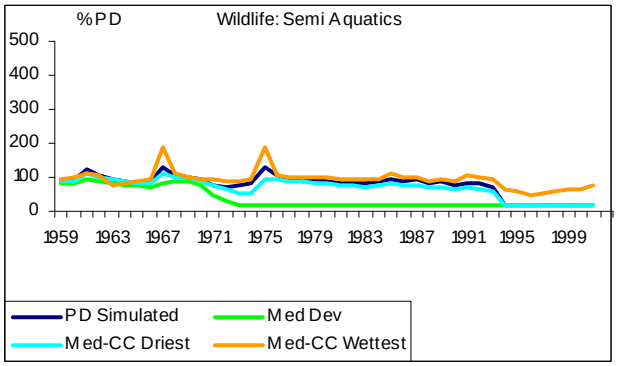
Site 4: Okavango River @ Rundu



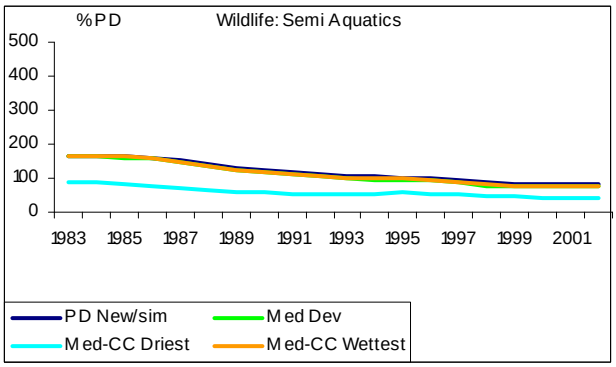
Site 5: Okavango River @ Popa Falls



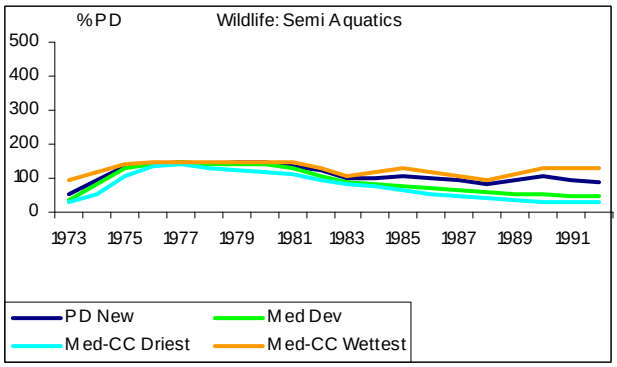
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

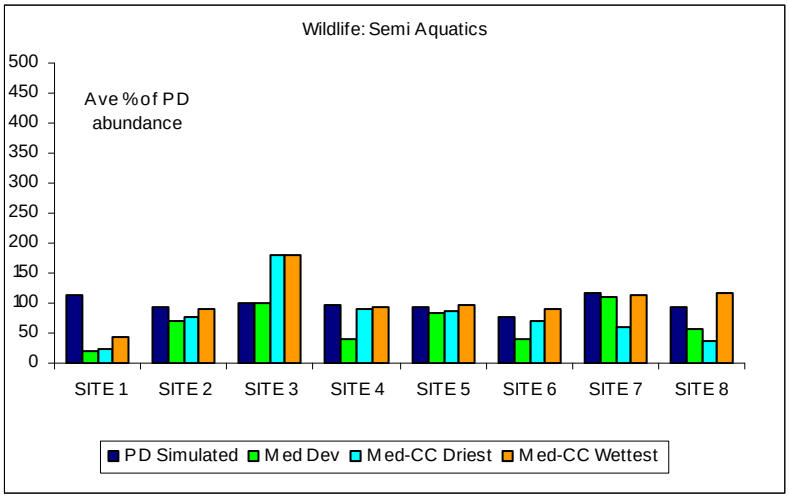


Site 8: Boteti River



Summary change per scenario

Particularly sensitive to dry season water depth for habitat and island integrity.



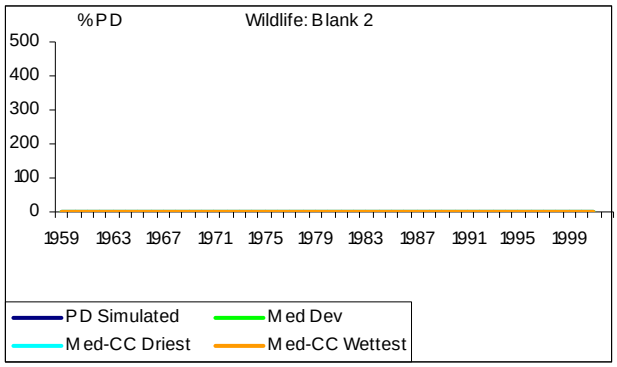
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

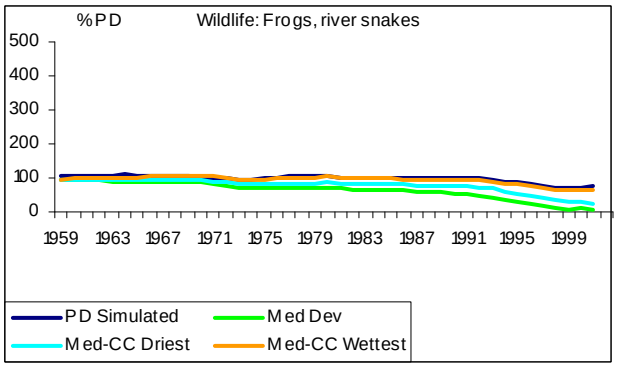
4.6.2 Frogs, river snakes

(Pools, permanent swamp, lower floodplain areas.)- Snakes, ridged frogs, musk shrews

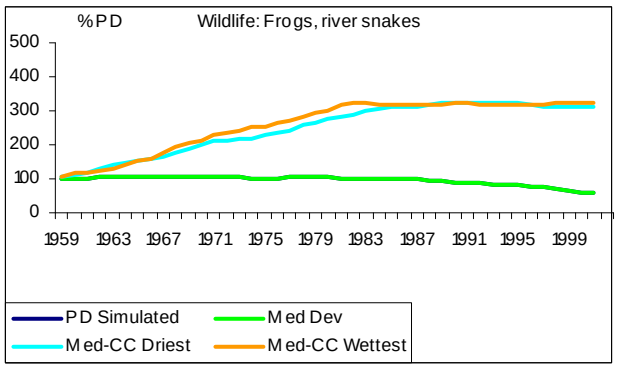
Site 1: Cubango River @ Capico



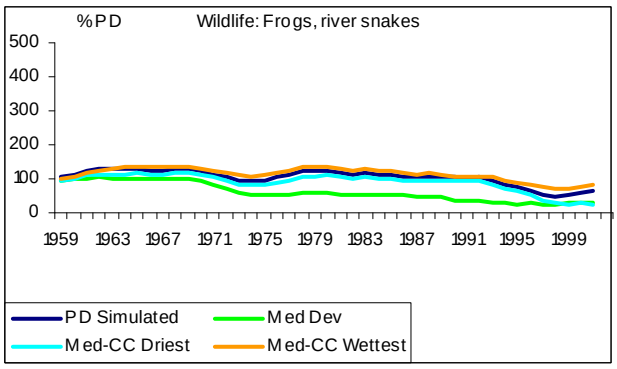
Site 2: Cubango River @ Mucundi



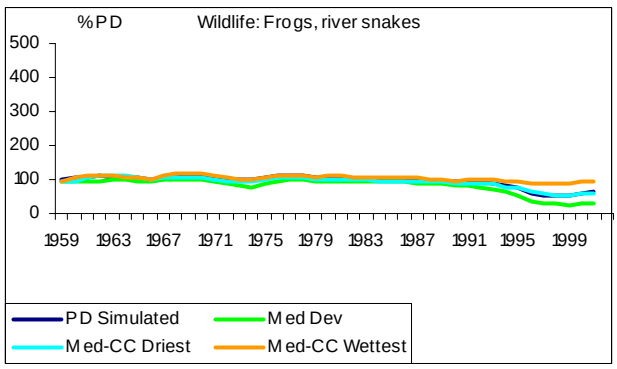
Site 3: Cuito River @ Cuito Cuanavale



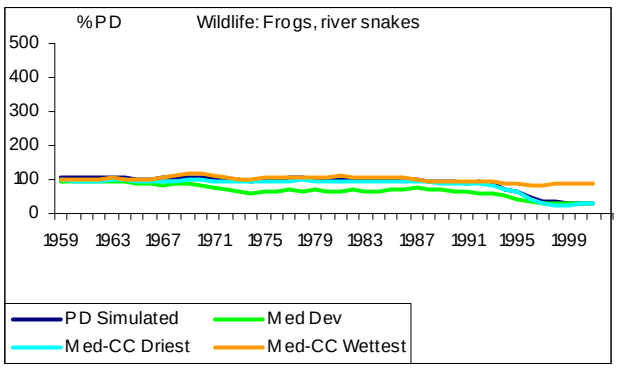
Site 4: Okavango River @ Rundu



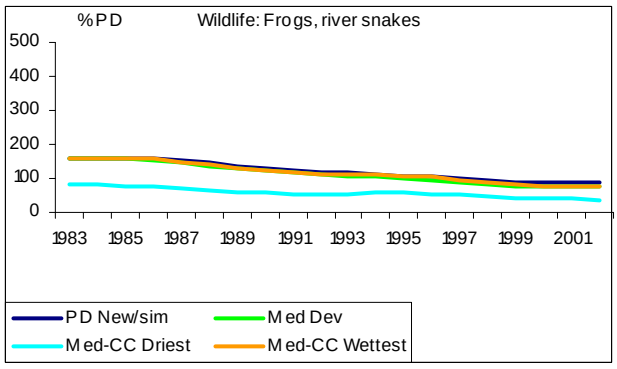
Site 5: Okavango River @ Popa Falls



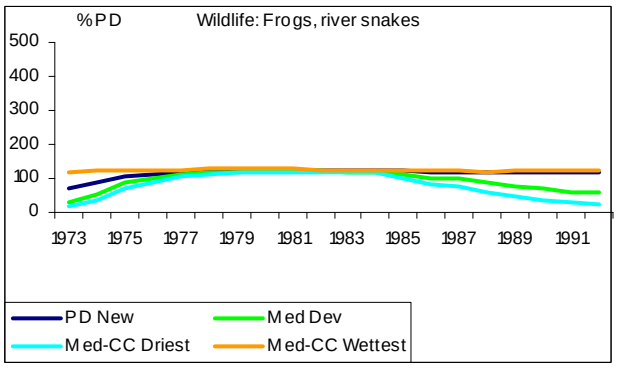
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

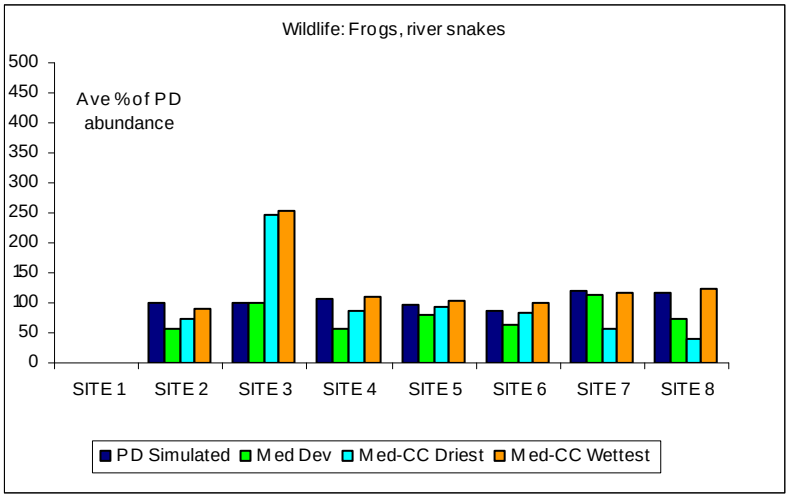


Site 8: Boteti River



Summary change per scenario

Particularly sensitive to dry season water levels and duration to maintain backwaters and marginal vegetation and reduced seasonal floods



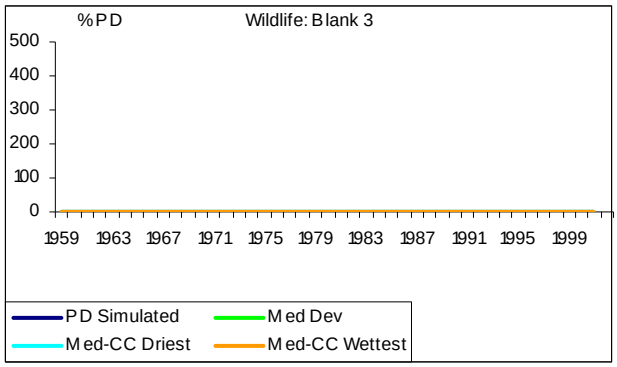
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

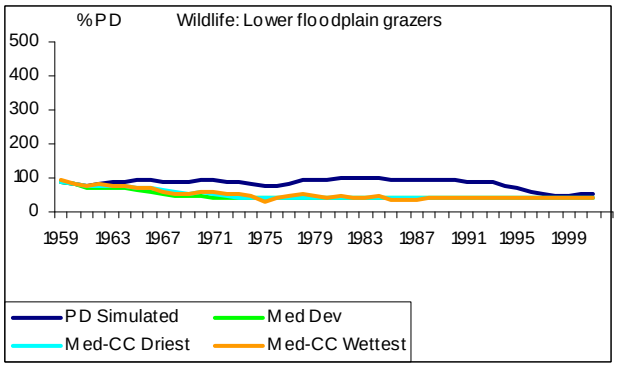
4.6.3 Lower floodplain grazers

(Primary and secondary floodplain)- Elephant, buffalo, tsesebe, warthog

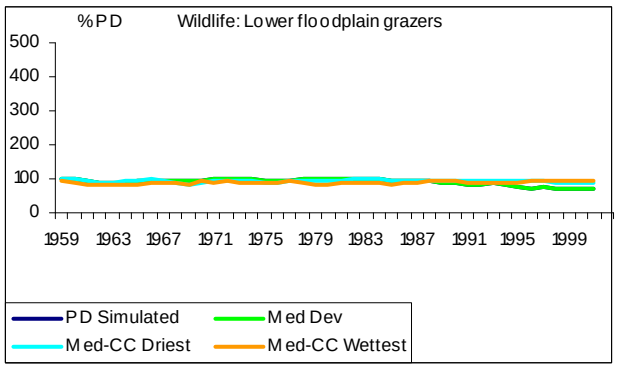
Site 1: Cubango River @ Capico



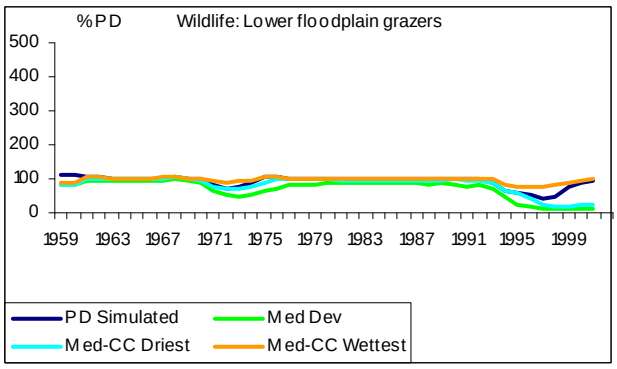
Site 2: Cubango River @ Mucundi



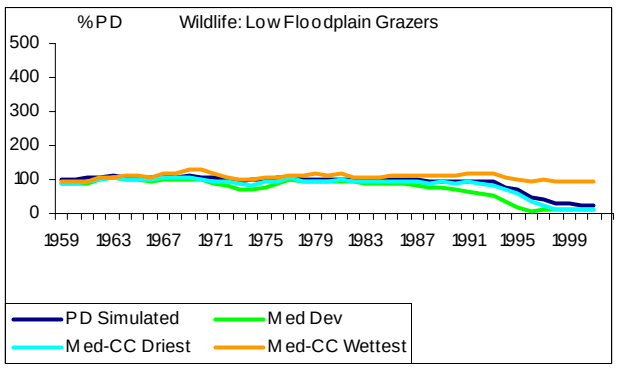
Site 3: Cuito River @ Cuito Cuanavale



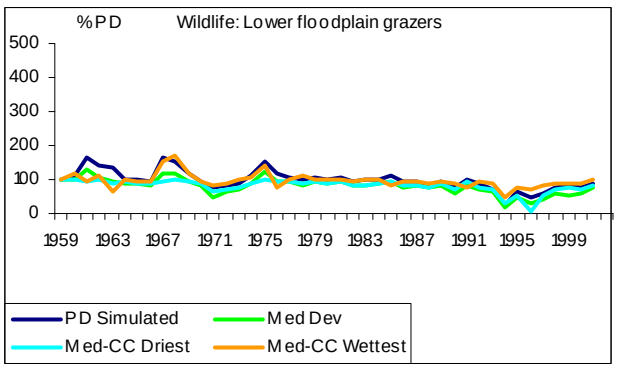
Site 4: Okavango River @ Rundu



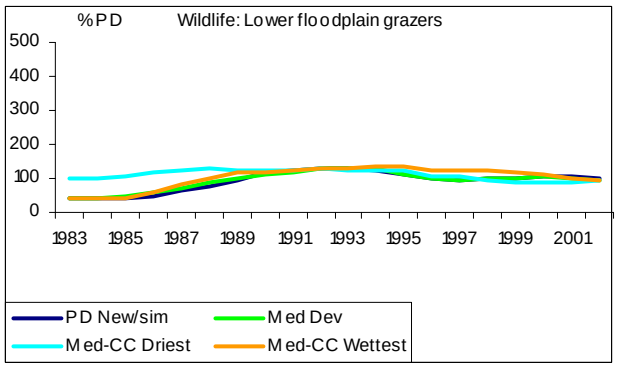
Site 5: Okavango River @ Popa Falls



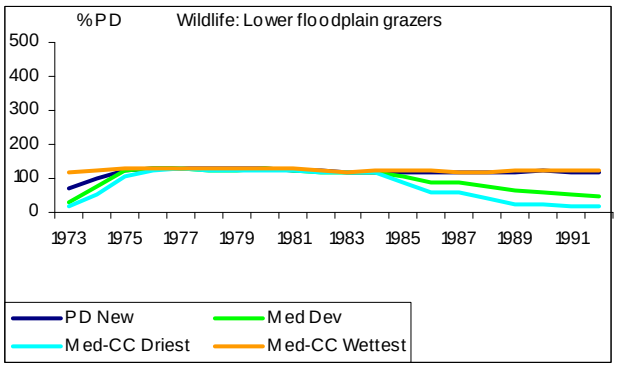
Site 6: Okavango River @ Pan Handle



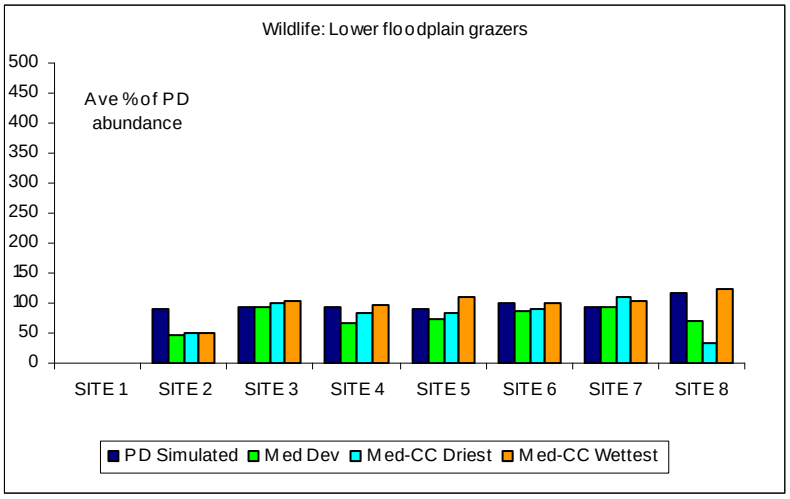
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Need to seasonal floods 2-6 months

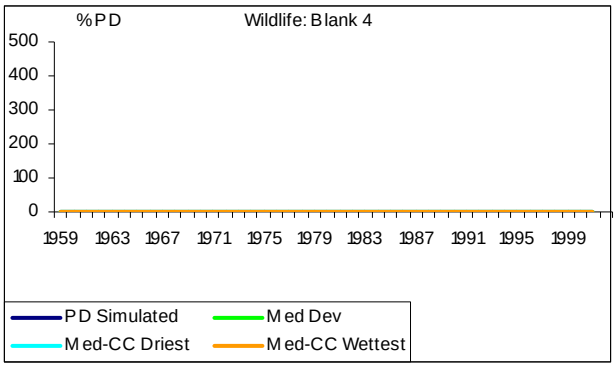


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

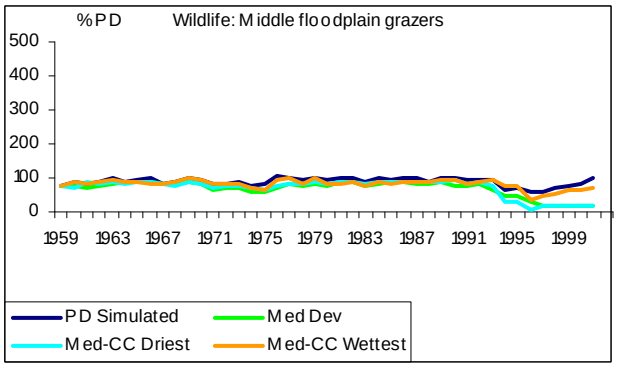
4.6.4 Middle floodplain grazers

(Secondary and tertiary floodplain)- Wildebeest, zebra, impala, duiker, aarvark, mice

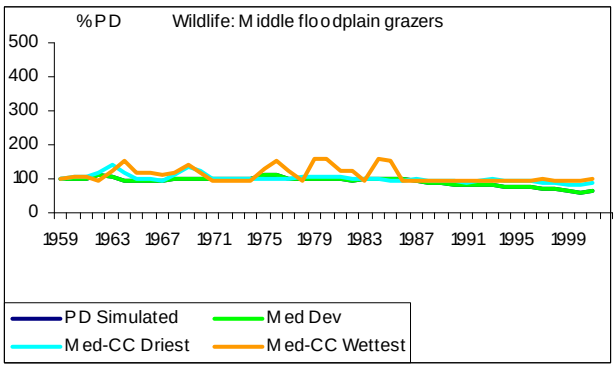
Site 1: Cubango River @ Capico



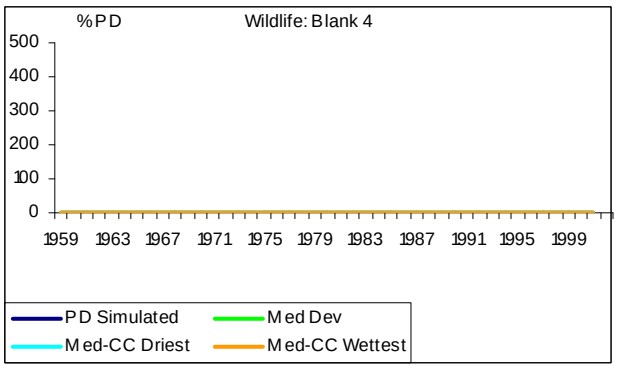
Site 2: Cubango River @ Mucundi



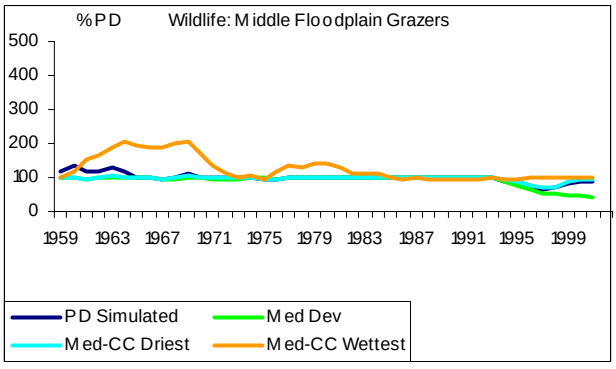
Site 3: Cuito River @ Cuito Cuanavale



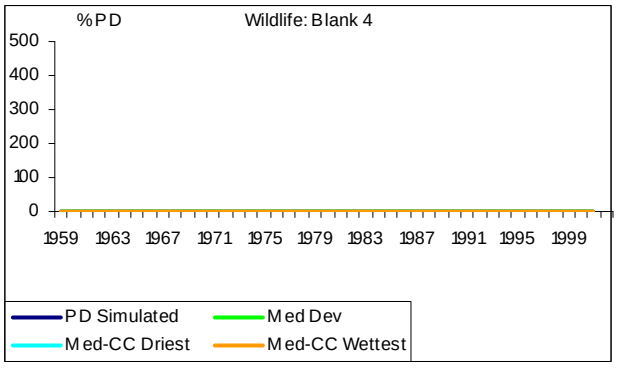
Site 4: Okavango River @ Rundu



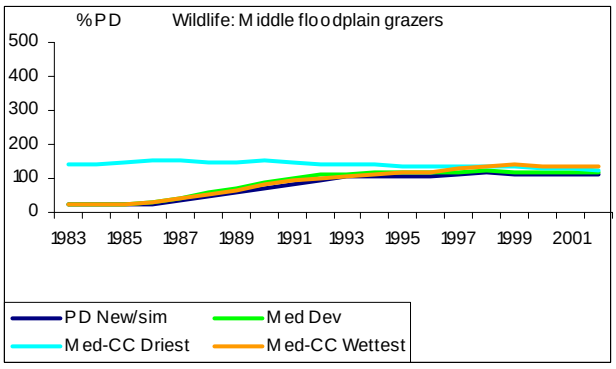
Site 5: Okavango River @ Popa Falls



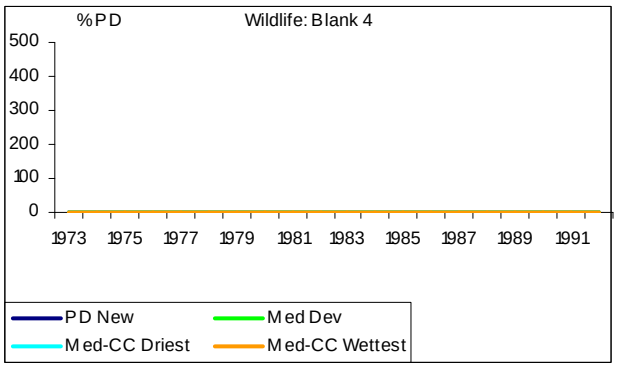
Site 6: Okavango River @ Pan Handle



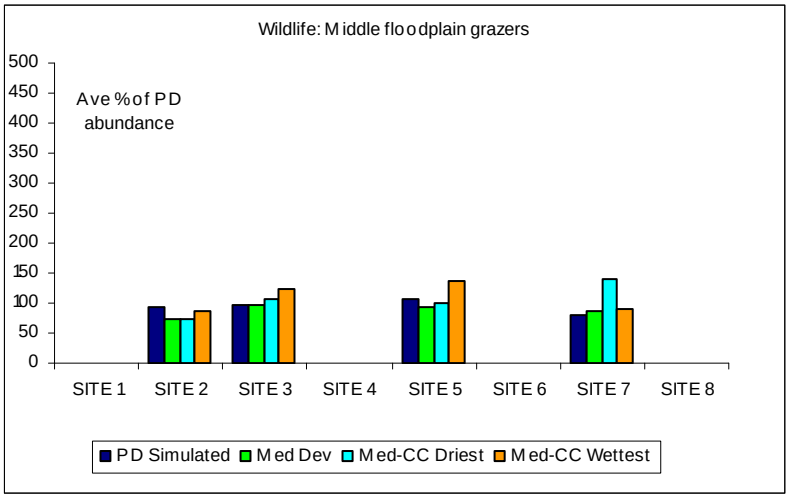
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
Need periodic flooding

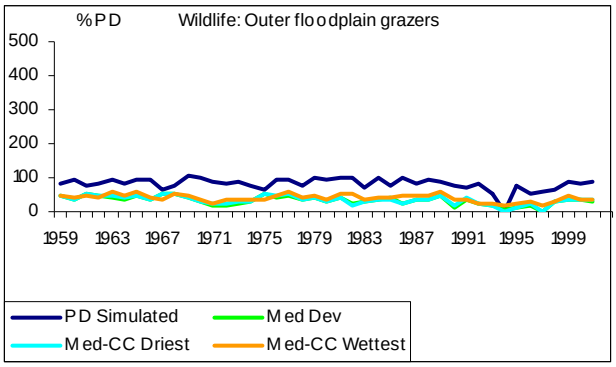


References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

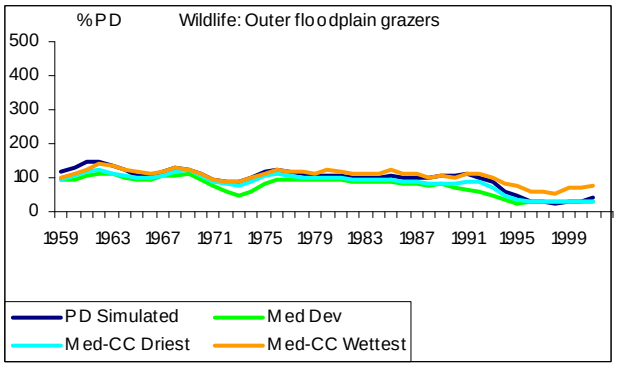
4.6.5 Outer floodplain grazers

(Permanent swamp , primary and secondary floodplain)- Lechwe, sitatunga, reedbuck, waterbuck,

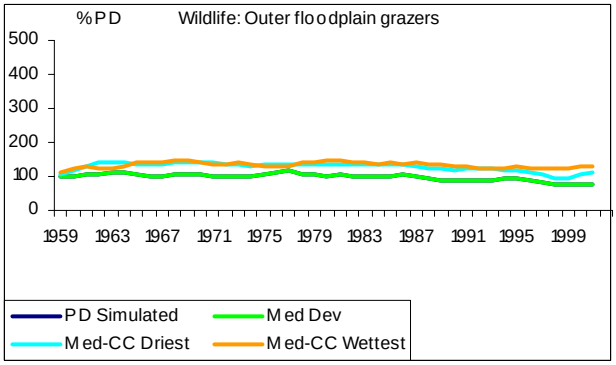
Site 1: Cubango River @ Capico



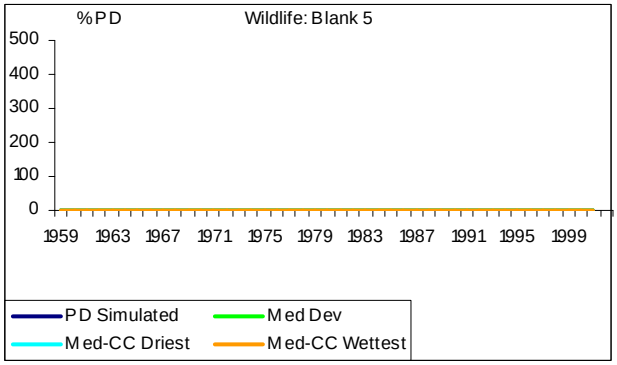
Site 2: Cubango River @ Mucundi



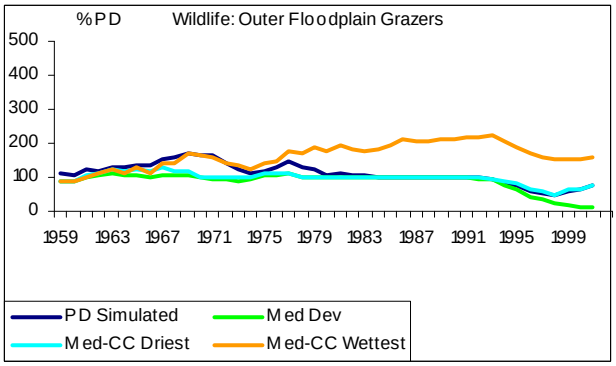
Site 3: Cuito River @ Cuito Cuanavale



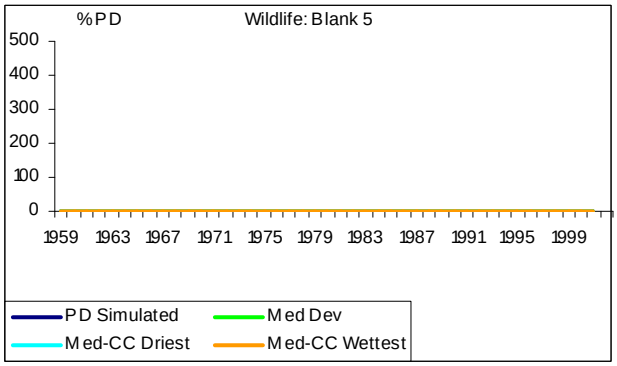
Site 4: Okavango River @ Rundu



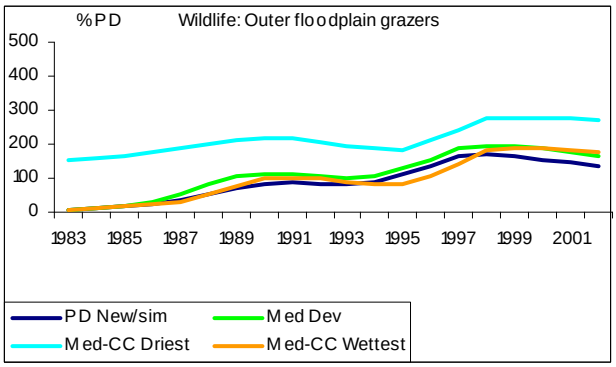
Site 5: Okavango River @ Popa Falls



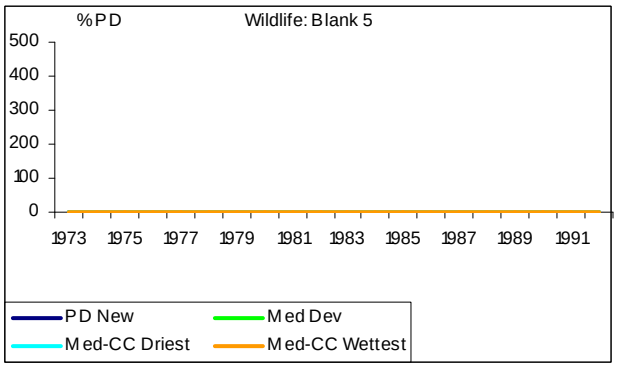
Site 6: Okavango River @ Pan Handle



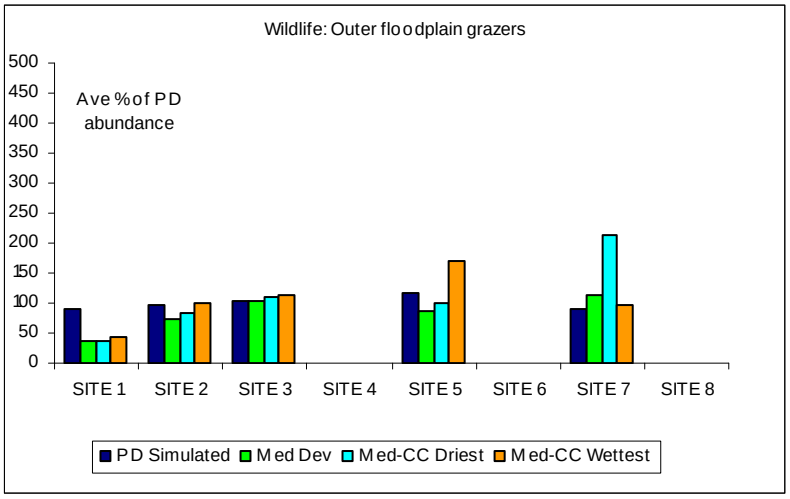
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario
need seasonal floods 4-6 months



References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4.7. Birds

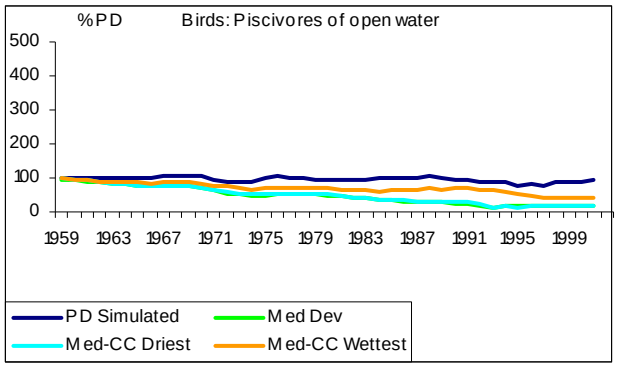
This section provides the time-series for bird indicators under the flow regime resulting from the medium scenario with and without climate change and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Piscivores - open water
- Piscivores - shallow water
- Piscivores and invertebrate feeders
- Specialists - floodplains
- Specialists - water lilies
- Specialists - fruit trees
- Breeders - reedbeds, floodplains
- Breeders - overhanging trees
- Breeders - banks
- Breeders - rocks, sandbars.

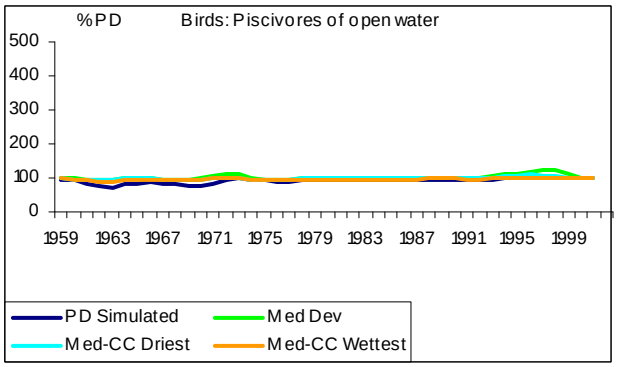
4.7.1 Piscivores, open water

(Predominantly feeds on fish, main river/adjoining pools)- Kingfishers, cormorants, darter

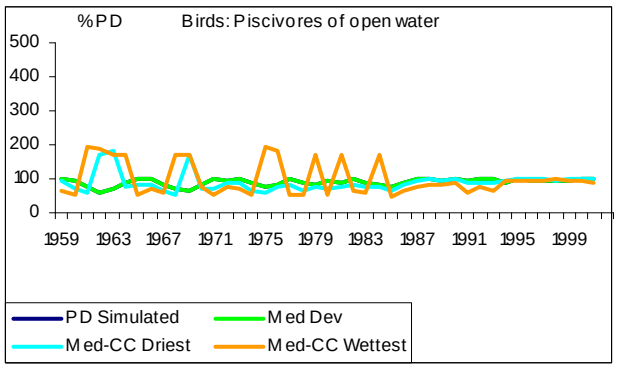
Site 1: Cubango River @ Capico



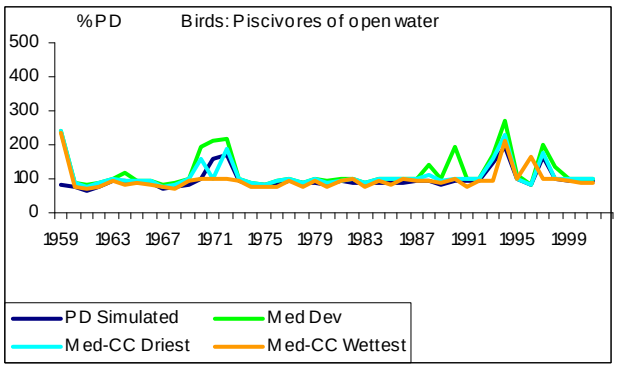
Site 2: Cubango River @ Mucundi



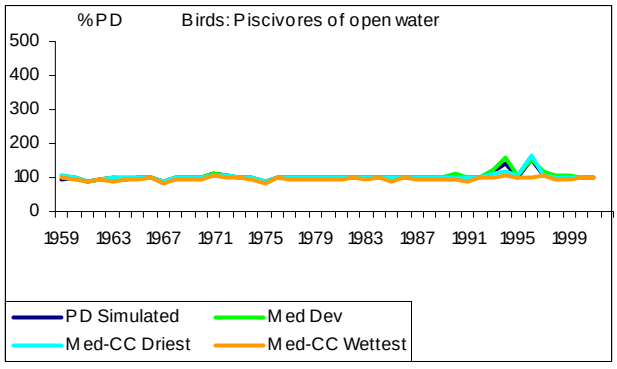
Site 3: Cuito River @ Cuito Cuanavale



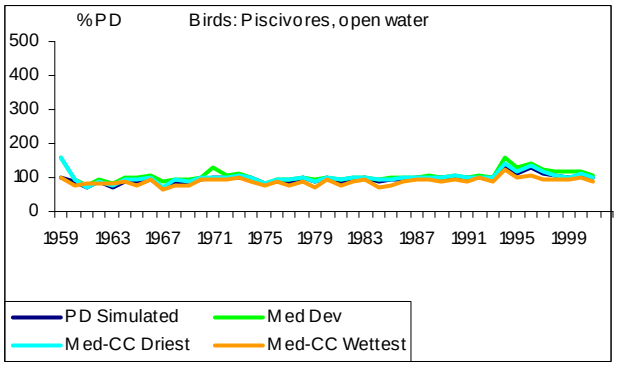
Site 4: Okavango River @ Rundu



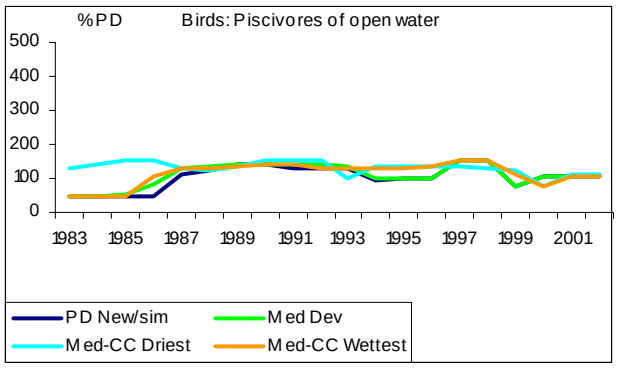
Site 5: Okavango River @ Popa Falls



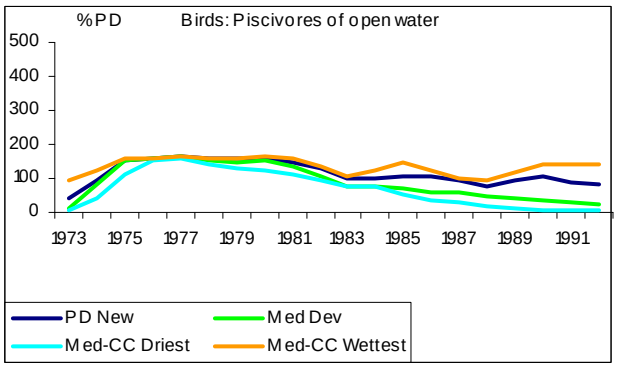
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

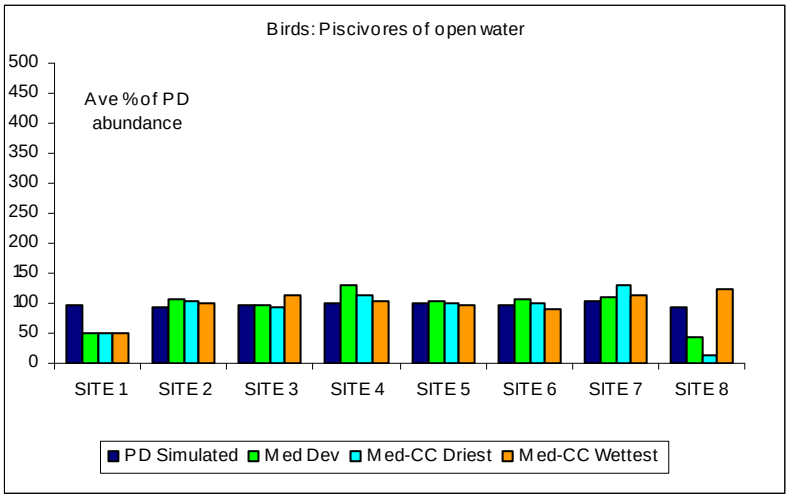


Site 8: Boteti River



Summary change per scenario

These birds generally thrive during low flow levels because their fish prey is more concentrated and vulnerable in the main river and/or isolated pools. However, at prolonged low flows or excessively low flows the prey base will be negatively affected if the floodplains where fish breed are not inundated.



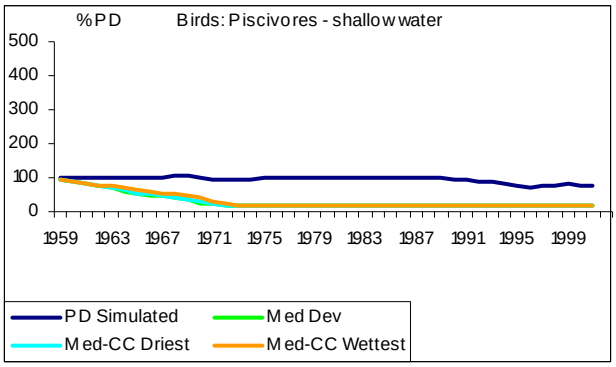
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

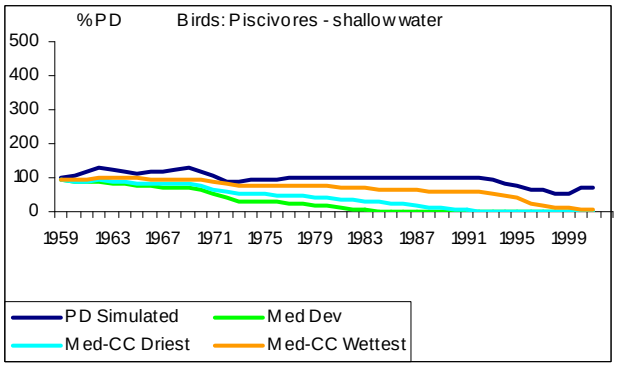
4.7.2 Piscivores, shallow water

(Hunts from overhanging trees on shallow backwaters by ambush techniques)- Larger herons/egrets

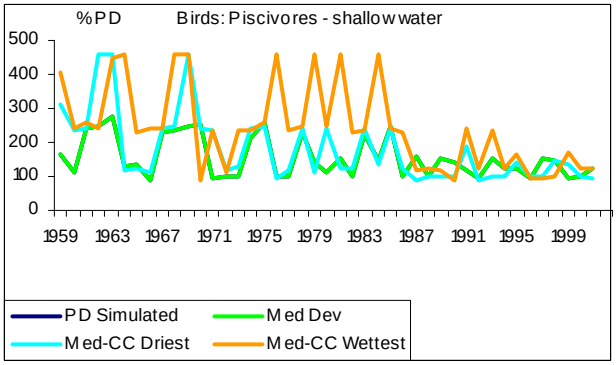
Site 1: Cubango River @ Capico



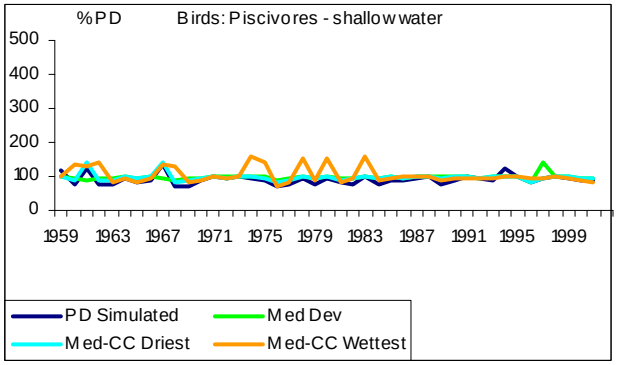
Site 2: Cubango River @ Mucundi



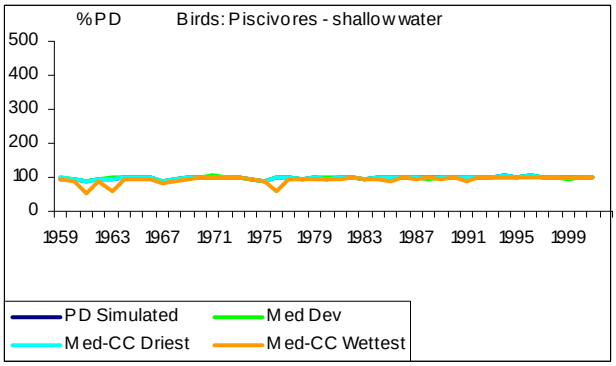
Site 3: Cuito River @ Cuito Cuanavale



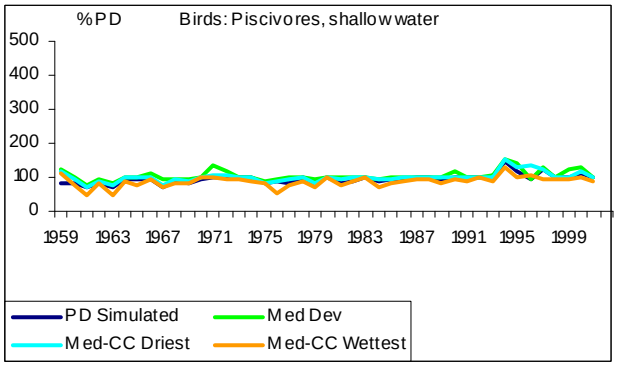
Site 4: Okavango River @ Rundu



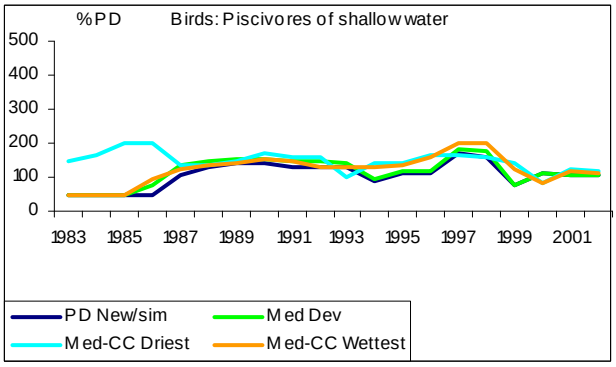
Site 5: Okavango River @ Popa Falls



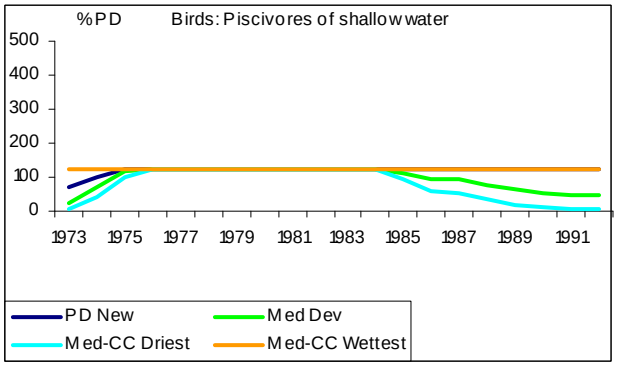
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

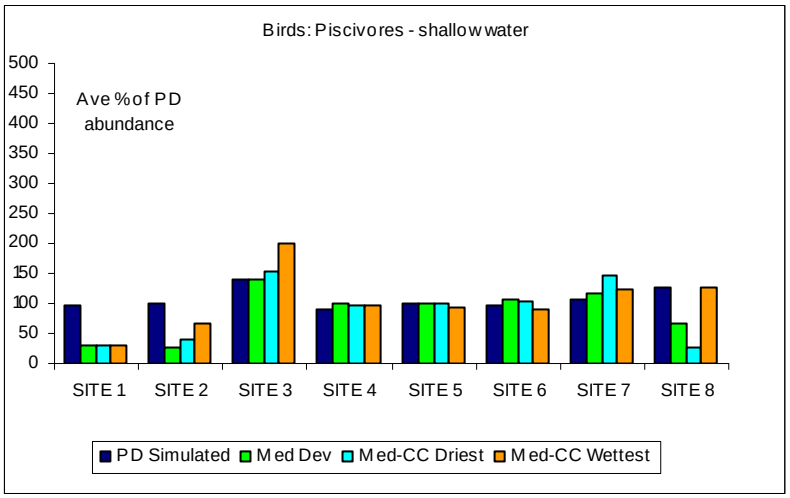


Site 8: Boteti River



Summary change per scenario

The shallower the water in the main channels and on the floodplains, the better for most of these species because prey would be confined into smaller concentrations and hunting opportunities would be improved.



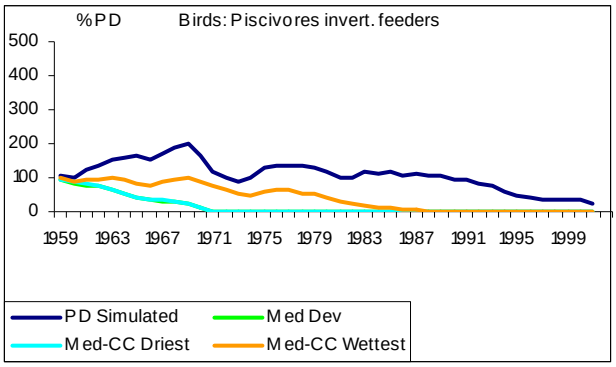
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

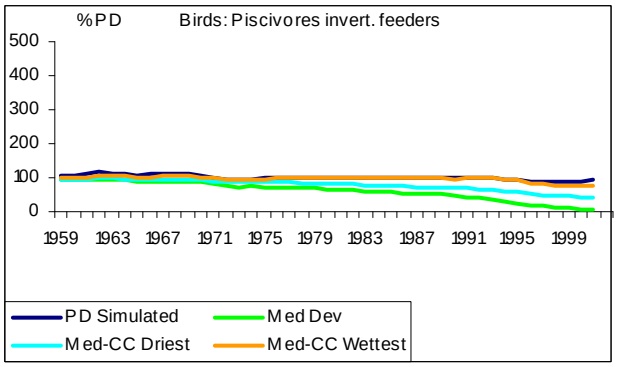
4.7.3 Piscivores invert. feeders

(Feed on fish-fry at receding water level times after spawning in flood-plains, or fish trapped in drying pools.)- Little Egret, Black Heron, Glossy Ibis, Saddle-billed Stork, Lapwings

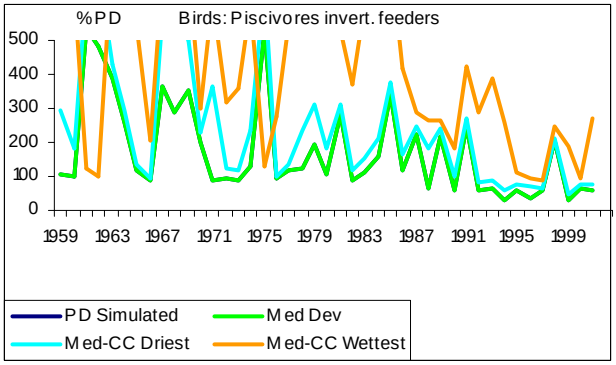
Site 1: Cubango River @ Capico



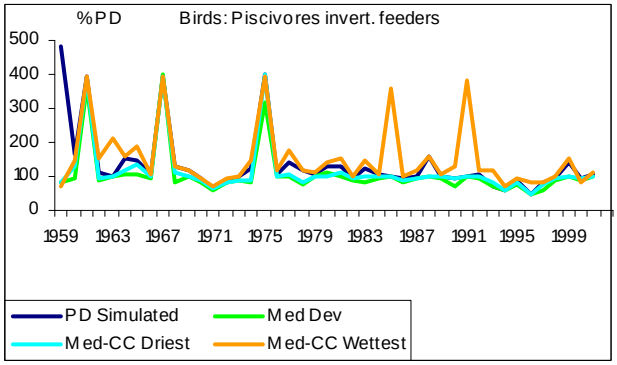
Site 2: Cubango River @ Mucundi



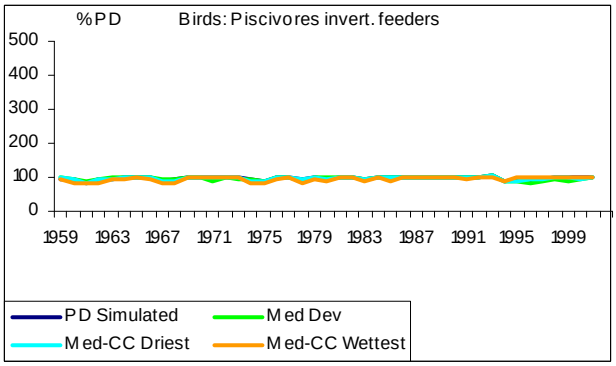
Site 3: Cuito River @ Cuito Cuanavale



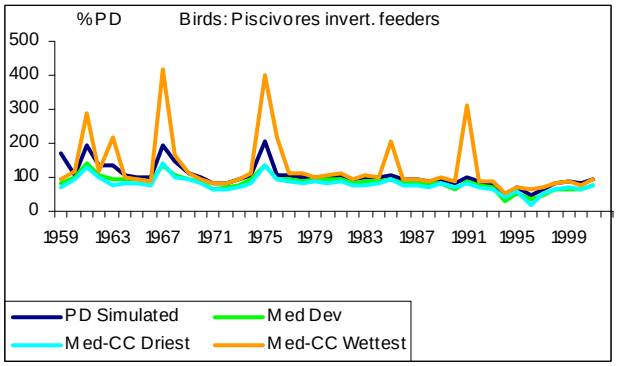
Site 4: Okavango River @ Rundu



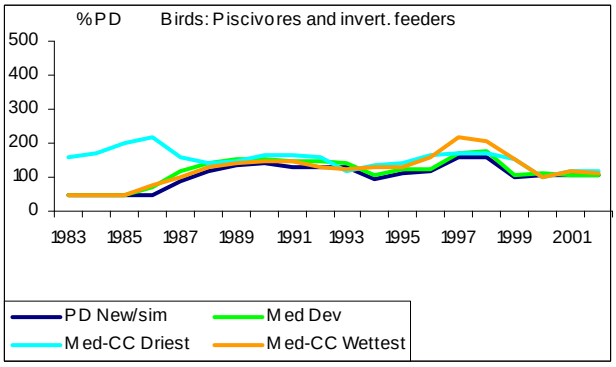
Site 5: Okavango River @ Popa Falls



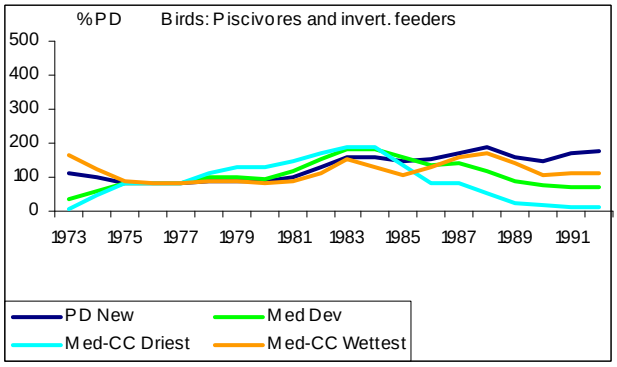
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

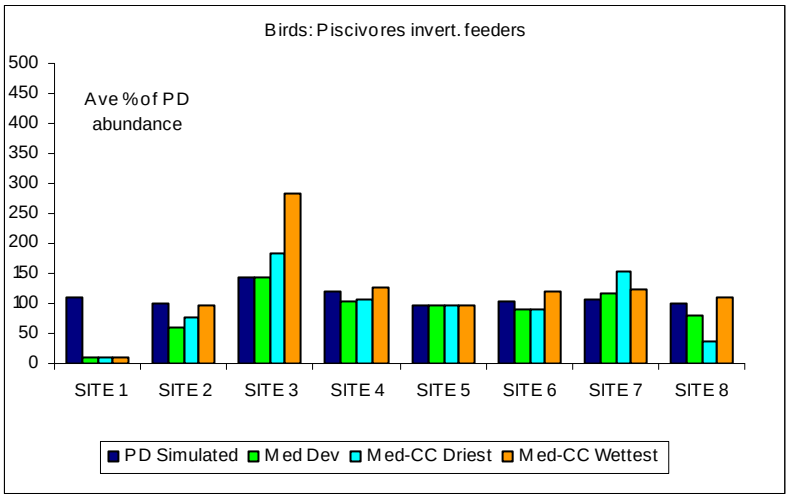


Site 8: Boteti River



Summary change per scenario

Timing and volume of flow are critical for these birds - when the river first overflows its banks onto the floodplains it causes optimal hunting and feeding conditions, and then again when receding waters cause isolated pools, trapping small fish and invertebrates.



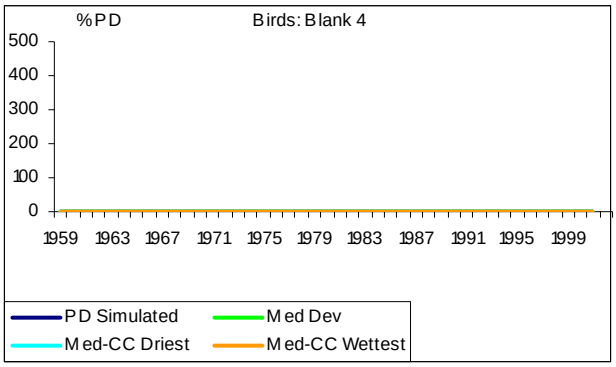
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

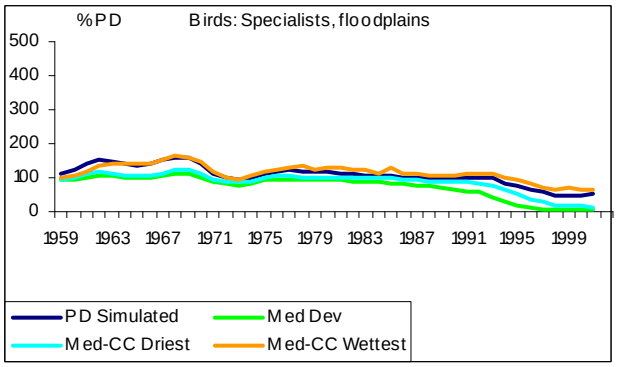
4.7.4 Specialists, floodplains

(Feed on molluscs, frogs, fish or selective vegetation and organisms occurring in shallow floodplain situations)- African Openbill, ducks, geese, Wattled Crane

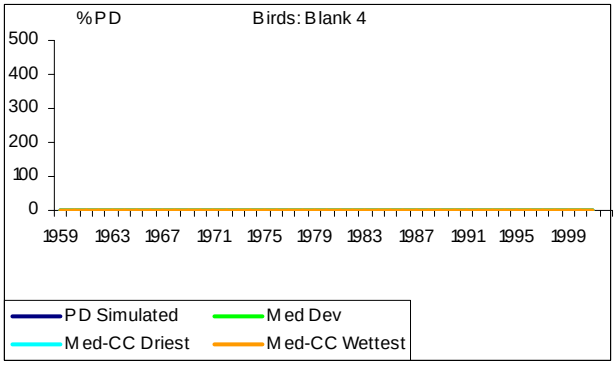
Site 1: Cubango River @ Capico



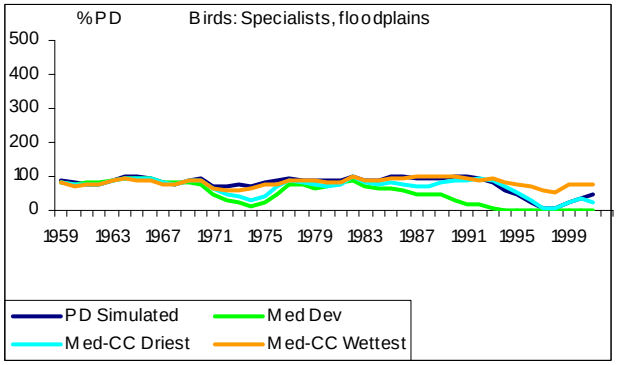
Site 2: Cubango River @ Mucundi



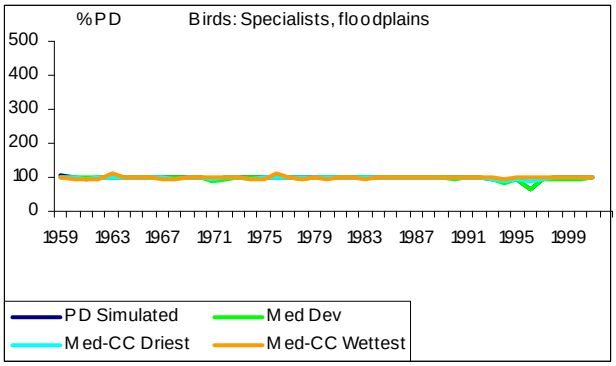
Site 3: Cuito River @ Cuito Cuanavale



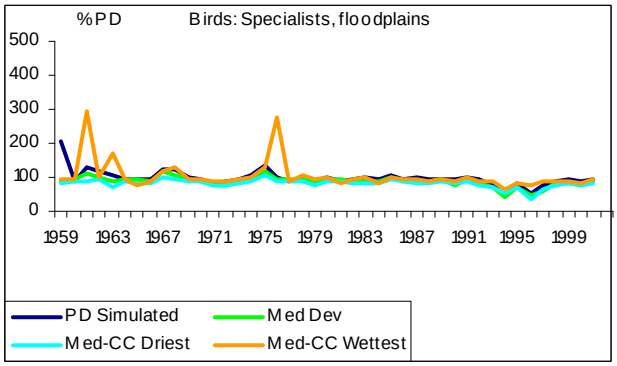
Site 4: Okavango River @ Rundu



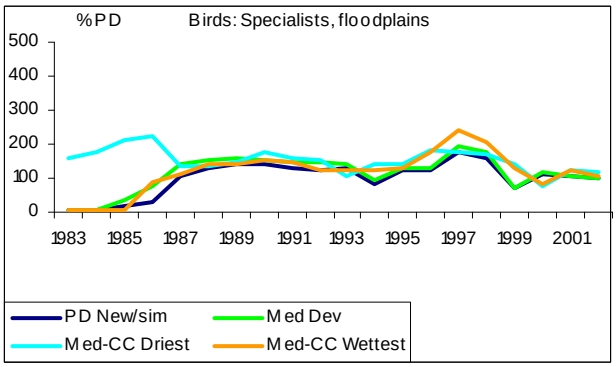
Site 5: Okavango River @ Popa Falls



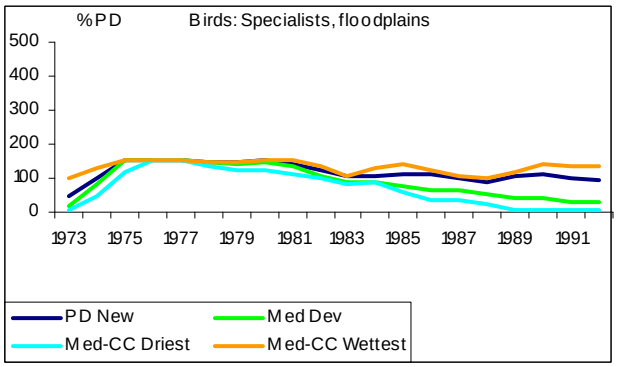
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

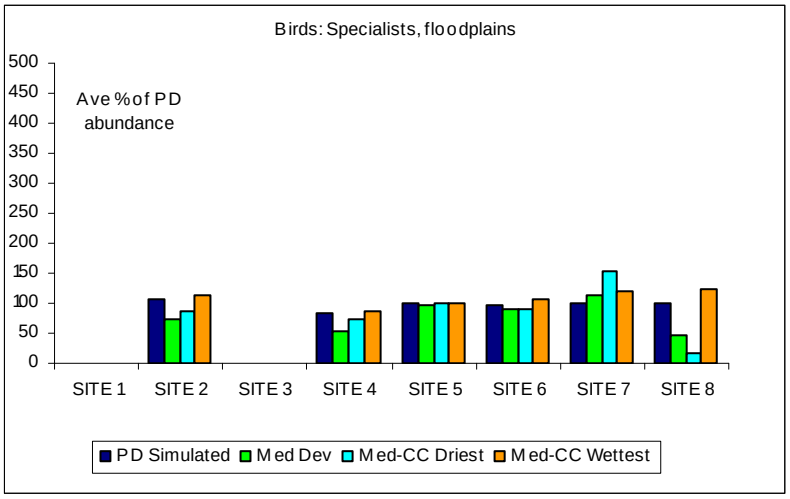


Site 8: Boteti River



Summary change per scenario

These birds utilise floodplain areas when they are newly flooded and food availability is at its optimal level due to new breeding and germination activities, and also when waters are receding and food items are confined and concentrated i.e. inundation and receding of waters is vitally important for this group of indicators.



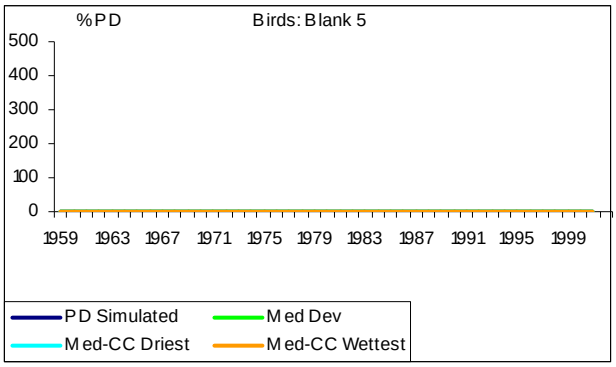
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

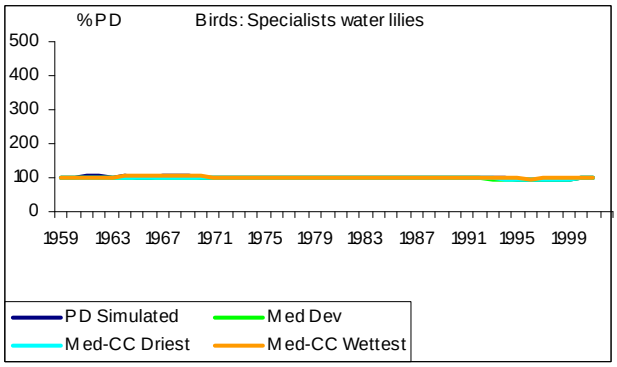
4.7.5 Specialists, water lilies

(Floodplain pools (rising and receding water levels) and lily-pad covered inlets. Essential for feeding habitat)- African and Lesser Jacanas

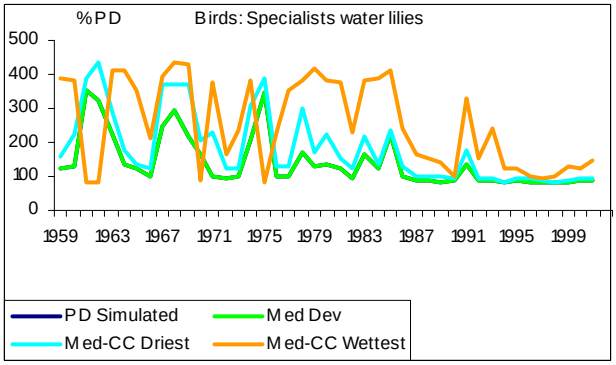
Site 1: Cubango River @ Capico



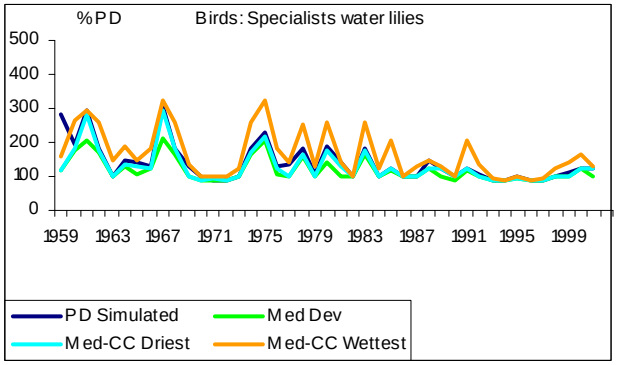
Site 2: Cubango River @ Mucundi



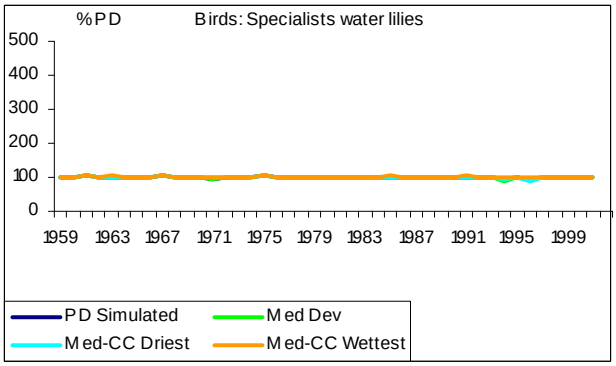
Site 3: Cuito River @ Cuito Cuanavale



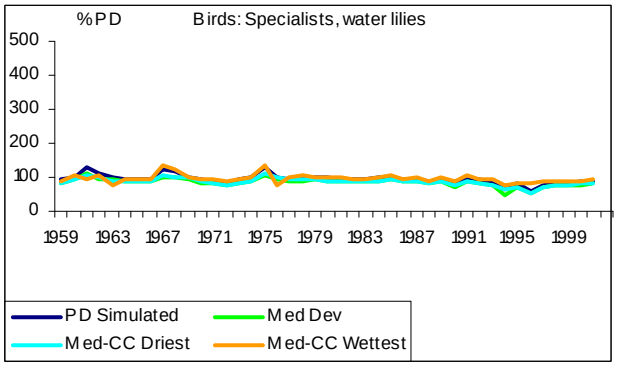
Site 4: Okavango River @ Rundu



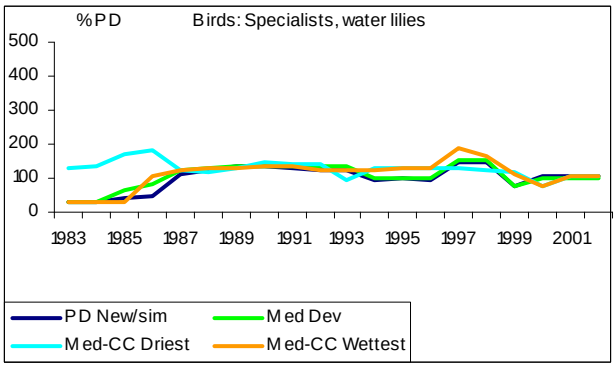
Site 5: Okavango River @ Popa Falls



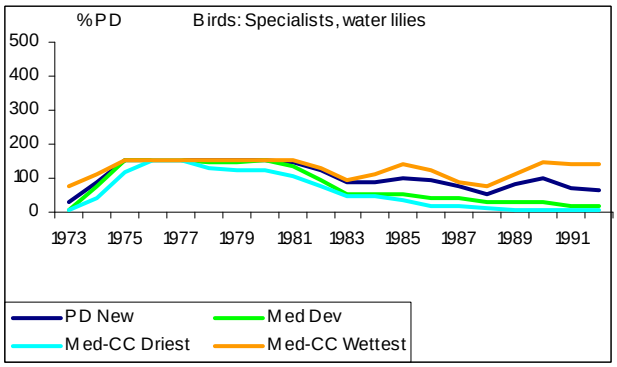
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

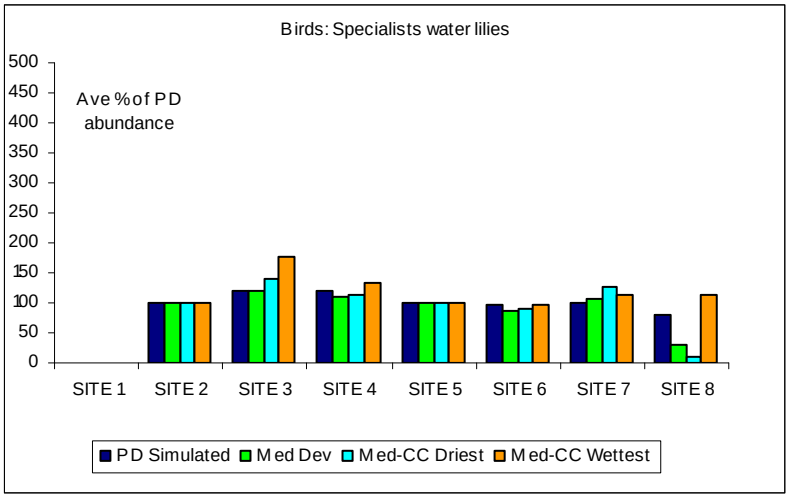


Site 8: Boteti River



Summary change per scenario

Whatever the flood regime, pockets of water lilies generally survive in backwaters, lagoons or isolated pools, providing suitable habitat for these birds.



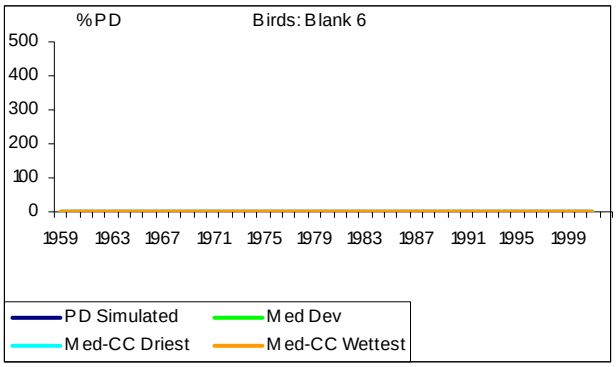
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

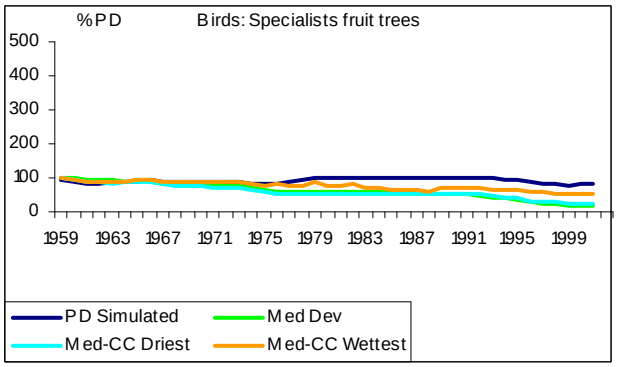
4.7.6 Specialists, fruit trees

(The Specialists, fruit trees category refers to specialist frugivores in riparian fruit trees. The response from the birds should mirror to some extent that for the plants (riparian trees) since if the riparian trees die due to low flows, there will not be a source of food for the birds When riverine fruit trees are in fruit they are an important food source for a large variety of birds.)- Turacos, bulbuls

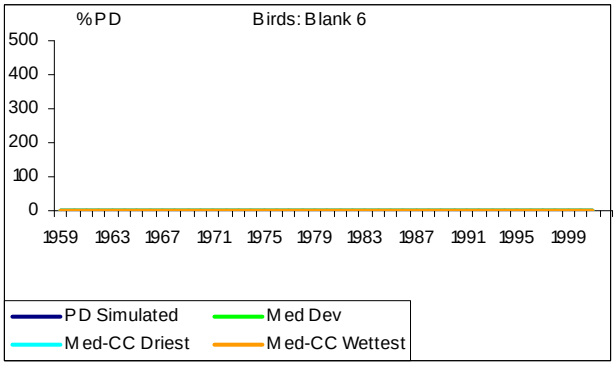
Site 1: Cubango River @ Capico



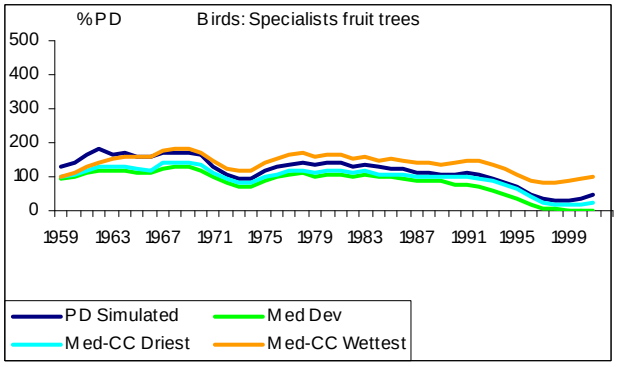
Site 2: Cubango River @ Mucundi



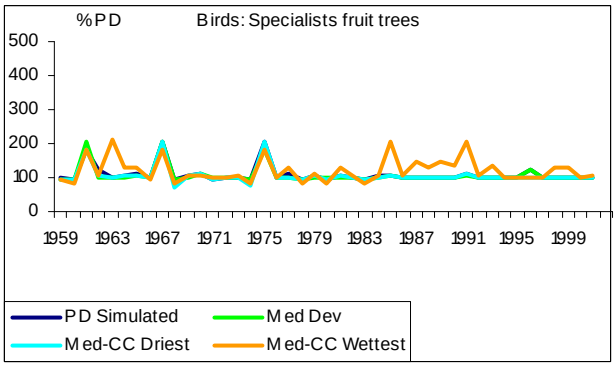
Site 3: Cuito River @ Cuito Cuanavale



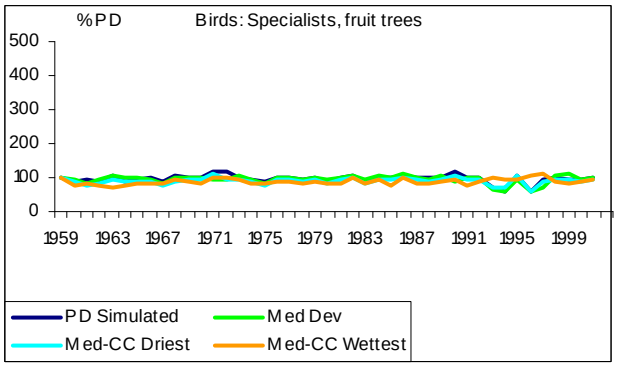
Site 4: Okavango River @ Rundu



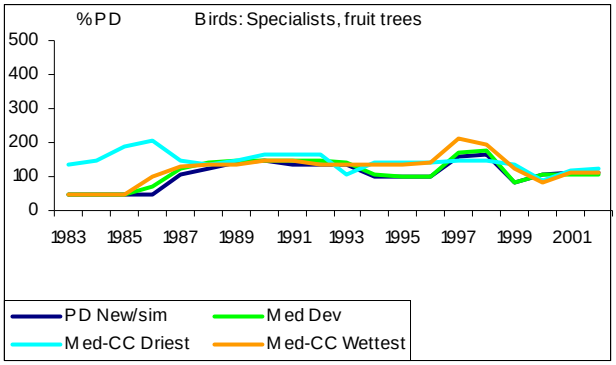
Site 5: Okavango River @ Popa Falls



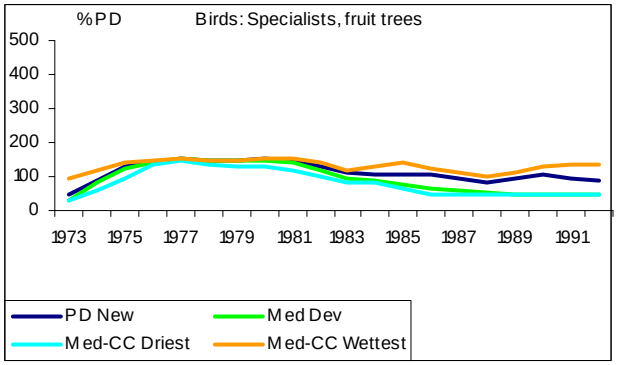
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

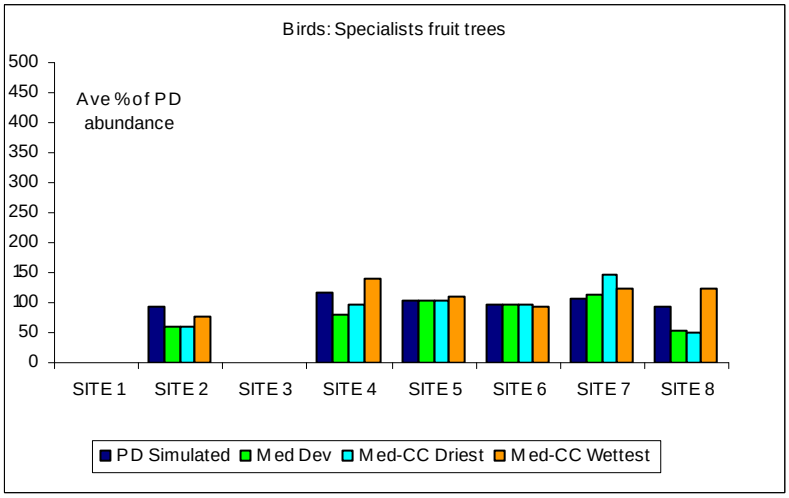


Site 8: Boteti River



Summary change per scenario

These birds will only be indirectly influenced by changes in water flows i.e. they depend on fruit bearing riparian trees that respond to changes in water flows. Because most of these tress are long-lived, there will be a time lag of several years before fruit production will fail when trees start dying from lack of water.



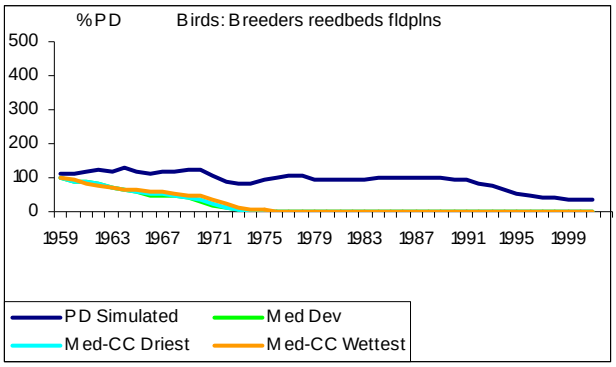
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

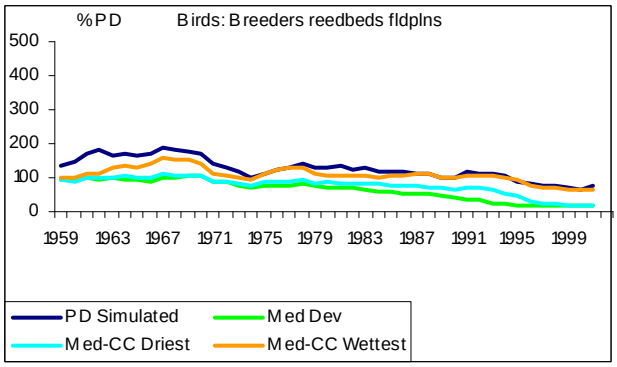
4.7.7 Breeders, reedbeds and fldplns

(Nesting habitat in reedbeds lining river banks and islands.)- Fan-tailed Widowbird, weavers, bishops, herons and egrets

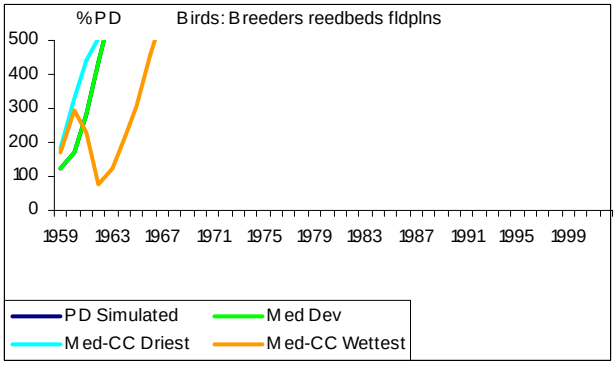
Site 1: Cubango River @ Capico



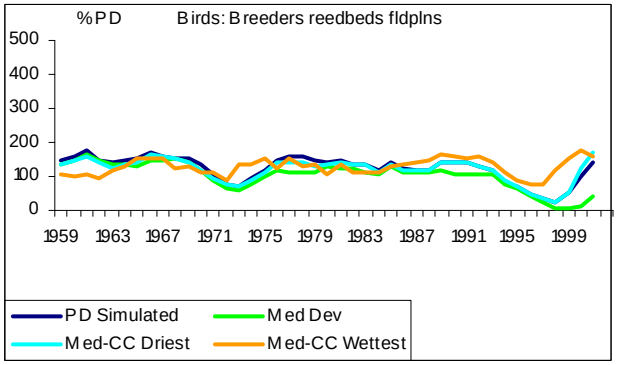
Site 2: Cubango River @ Mucundi



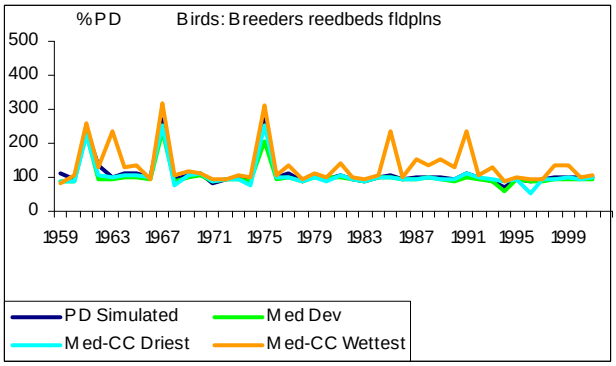
Site 3: Cuito River @ Cuito Cuanavale



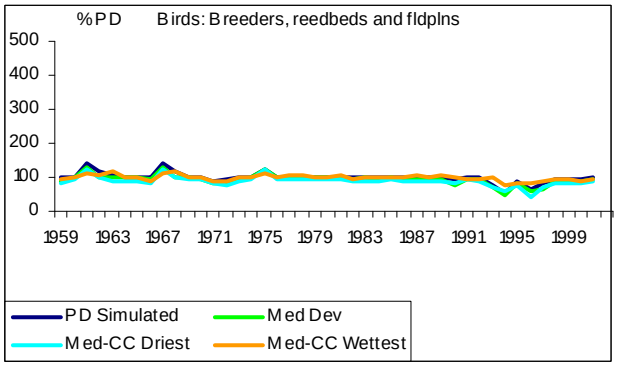
Site 4: Okavango River @ Rundu



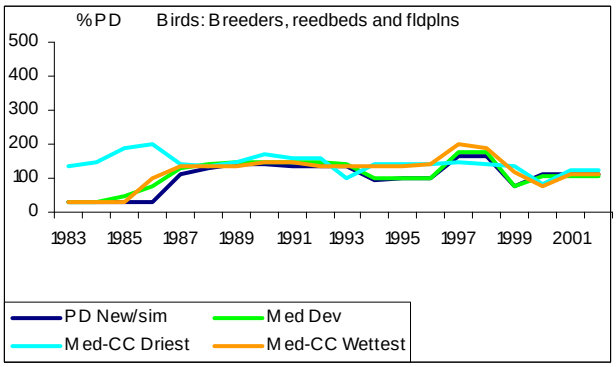
Site 5: Okavango River @ Popa Falls



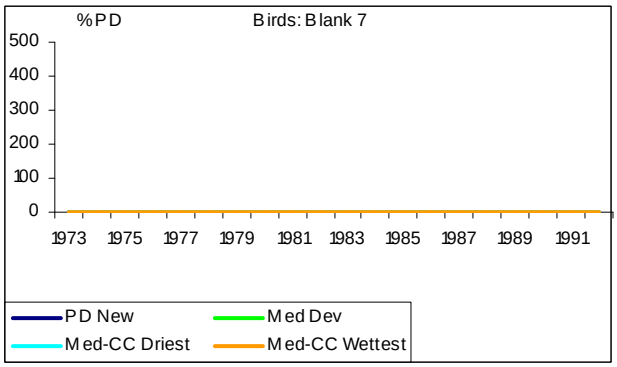
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

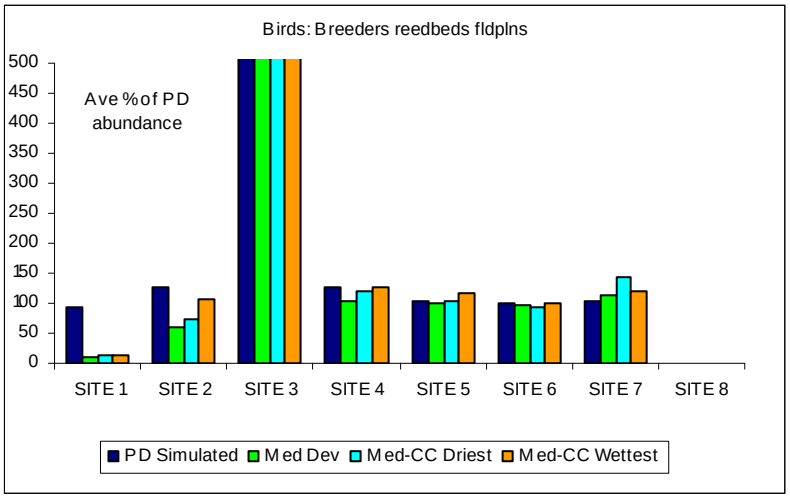


Site 8: Boteti River



Summary change per scenario

These birds must have reedbeds and other vegetation standing in water, in which to build nests as a protective mechanism against predator access to their nests. Therefore, these birds generally wait for optimal high water leves before constructing nests so that nest flooding does not occur by rising waters, and the water level persists throughout the breeding cycle.



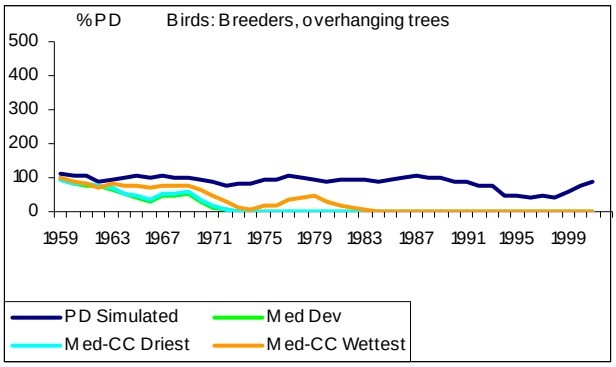
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

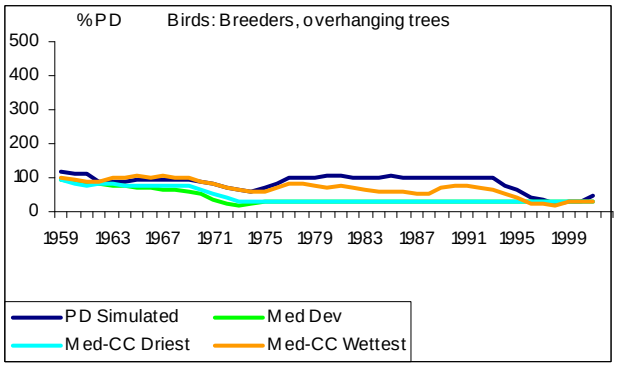
4.7.8 Breeders, overhanging trees

(Colonial breeders or solitary nesters requiring over-hanging vegetation for nest safety or fledglings vacating the nest)- Herons, cormorants, darters

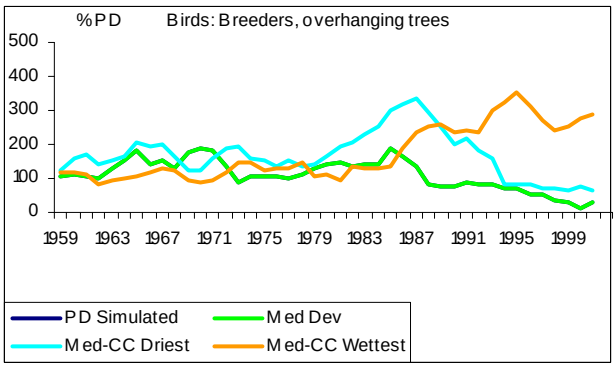
Site 1: Cubango River @ Capico



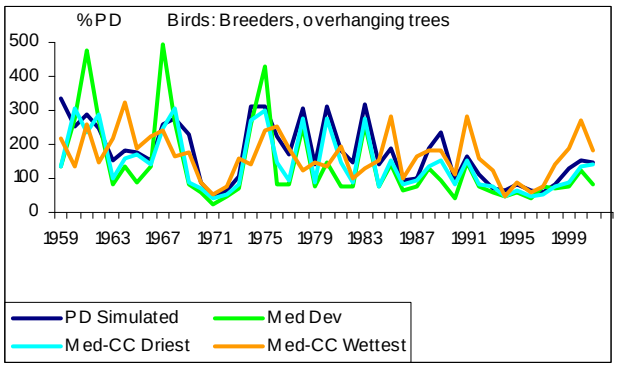
Site 2: Cubango River @ Mucundi



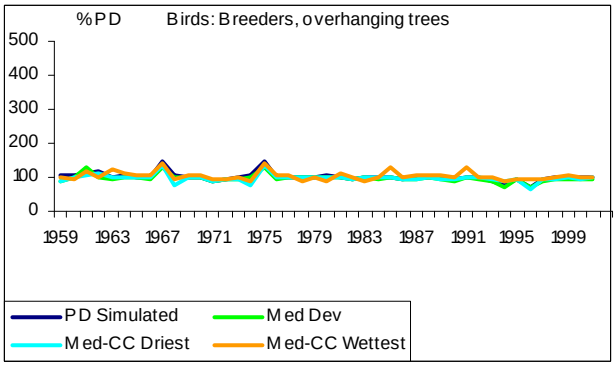
Site 3: Cuito River @ Cuito Cuanavale



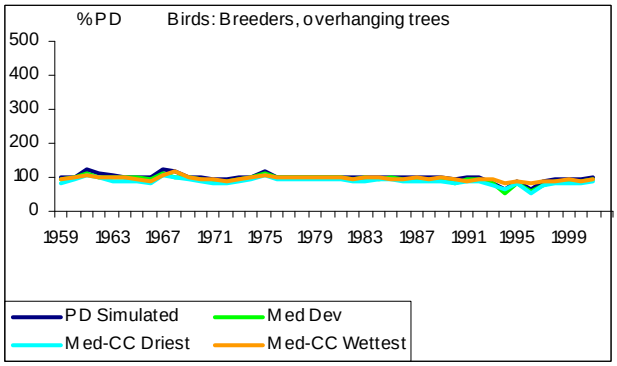
Site 4: Okavango River @ Rundu



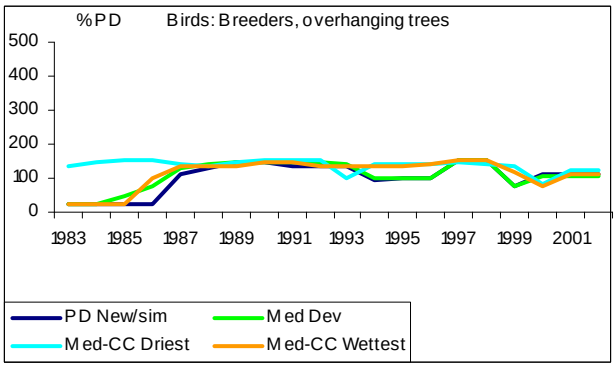
Site 5: Okavango River @ Popa Falls



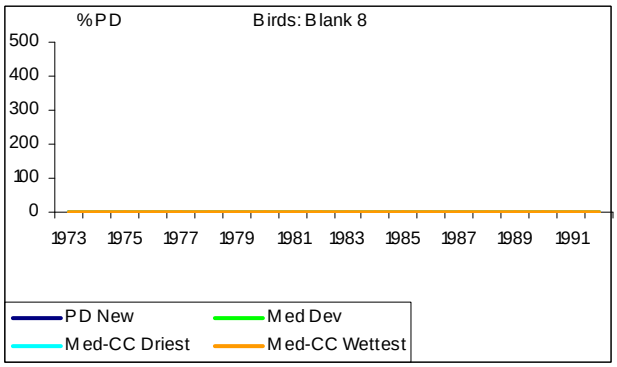
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

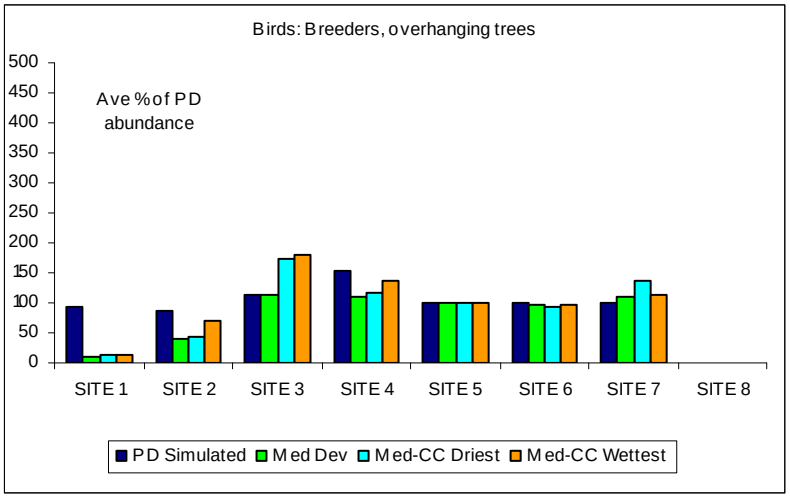


Site 8: Boteti River



Summary change per scenario

Trees overhanging water are critical to the breeding success of these birds for two reasons: protection against predators, and for refuge by chicks when disturbed.



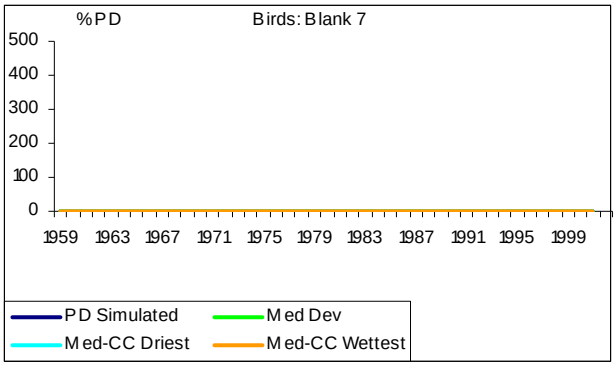
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

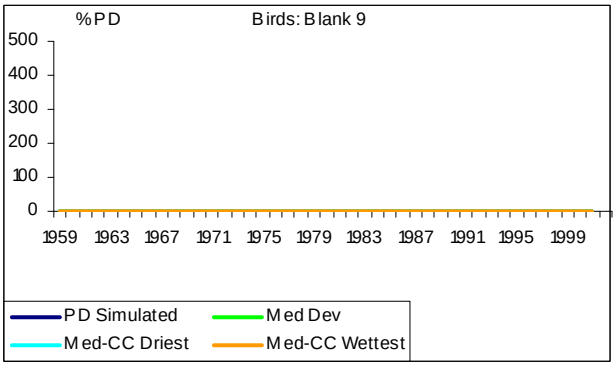
4.7.9 Breeders, banks

(Require vertical banks for nest holes or the grassy banks for nest sites and fledgling development (Note that kingfishers have been excluded))- Bee-eaters, Collared Pratincoles, lapwings

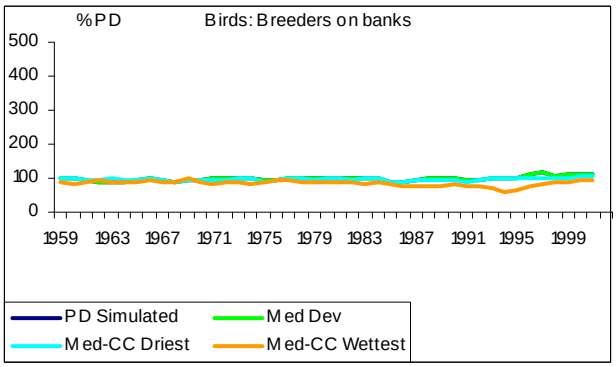
Site 1: Cubango River @ Capico



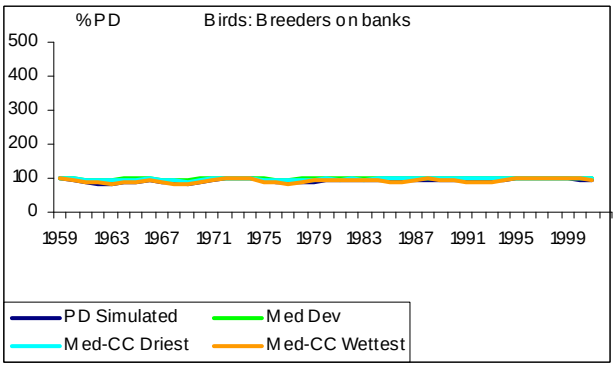
Site 2: Cubango River @ Mucundi



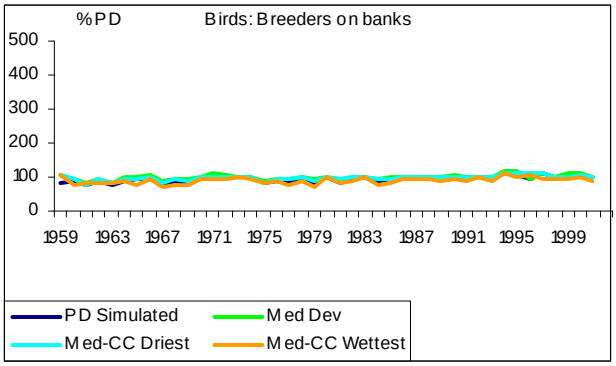
Site 3: Cuito River @ Cuito Cuanavale



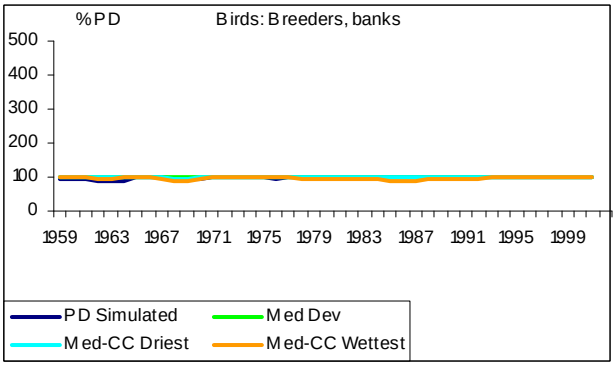
Site 4: Okavango River @ Rundu



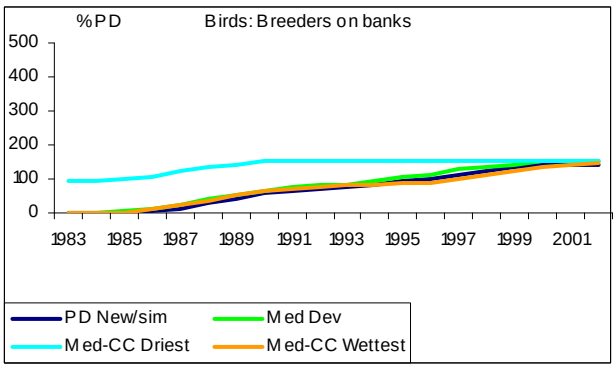
Site 5: Okavango River @ Popa Falls



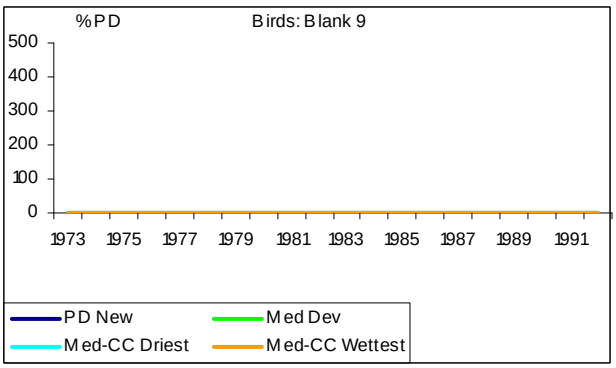
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

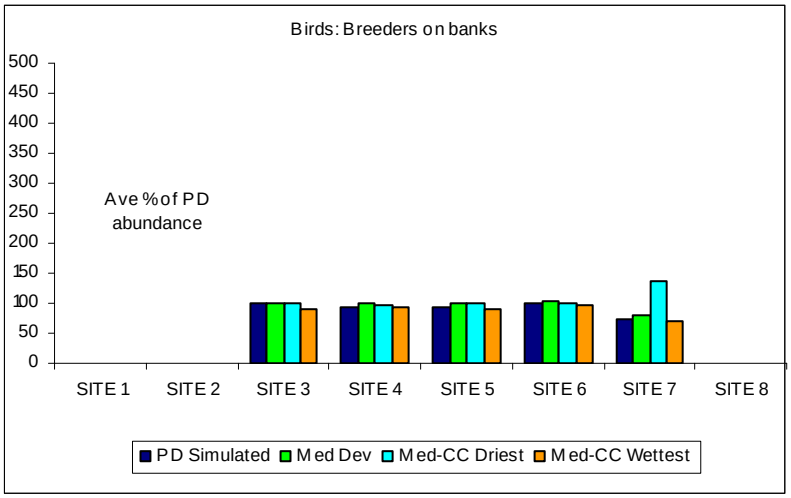


Site 8: Boteti River



Summary change per scenario

These birds are influenced only by reliably lowering water levels to expose vertical or grassy banks for breeding purposes - they are not necessarily dependent on the river flow for their food supply.



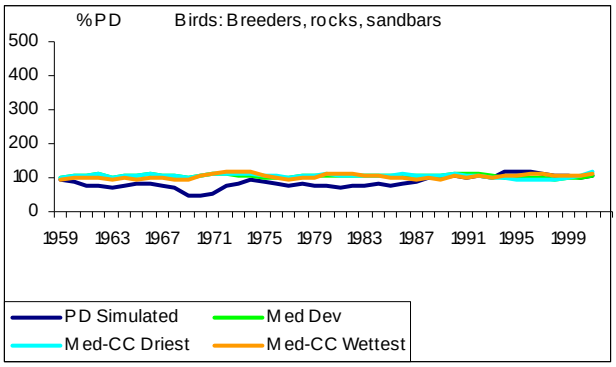
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

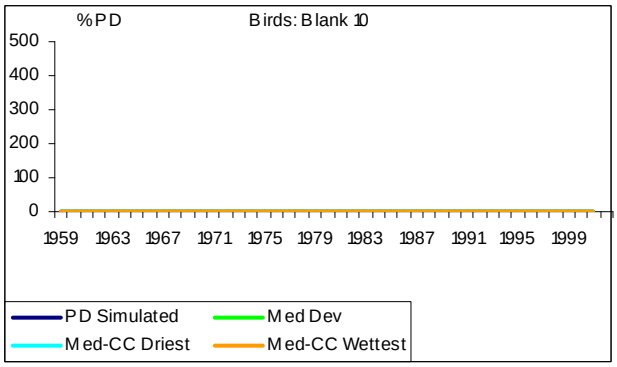
4.7.10 Breeders, rocks, sandbars

(Totally dependent on emerged rocks, sandbars and islands in the main river for nesting purposes)- Rock Pratincole, African Skimmer, sandpipers, thick-knees

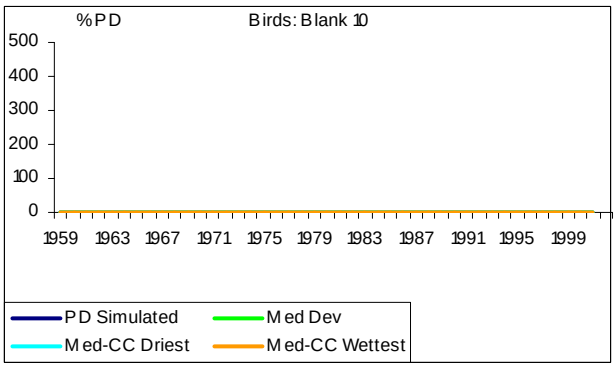
Site 1: Cubango River @ Capico



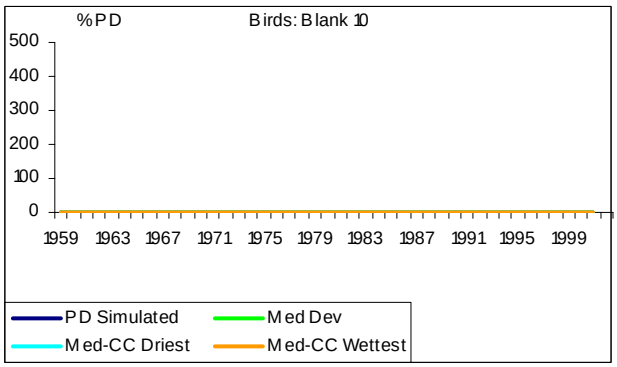
Site 2: Cubango River @ Mucundi



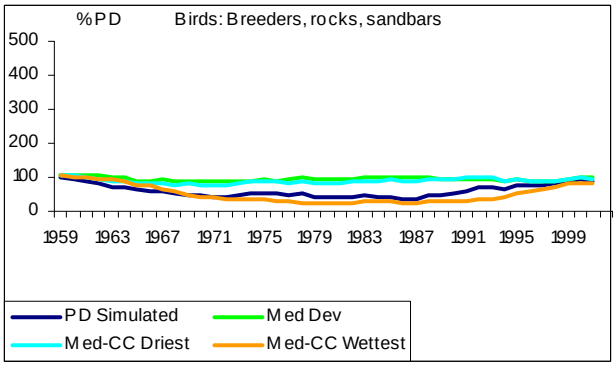
Site 3: Cuito River @ Cuito Cuanavale



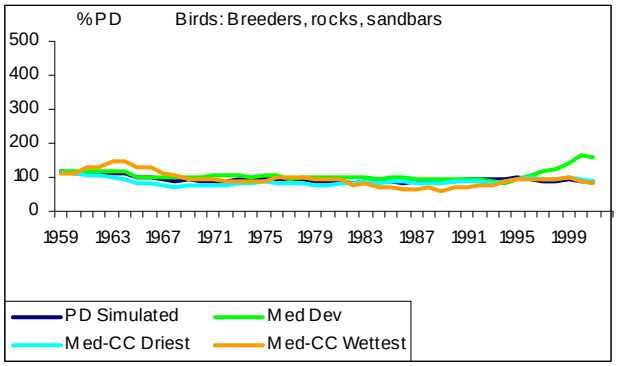
Site 4: Okavango River @ Rundu



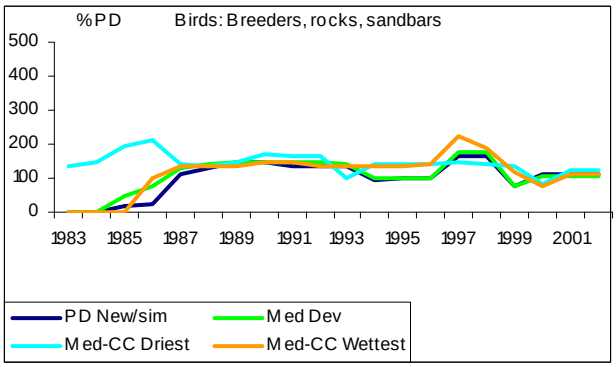
Site 5: Okavango River @ Popa Falls



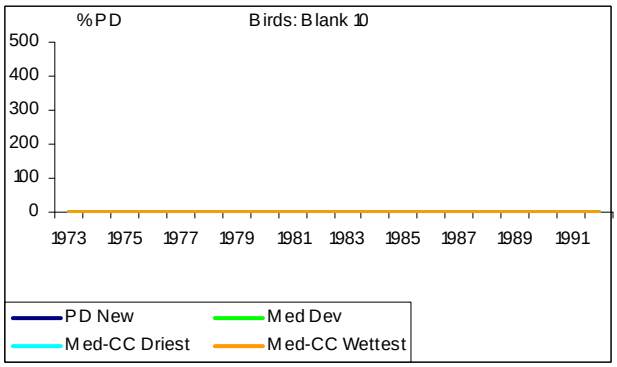
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

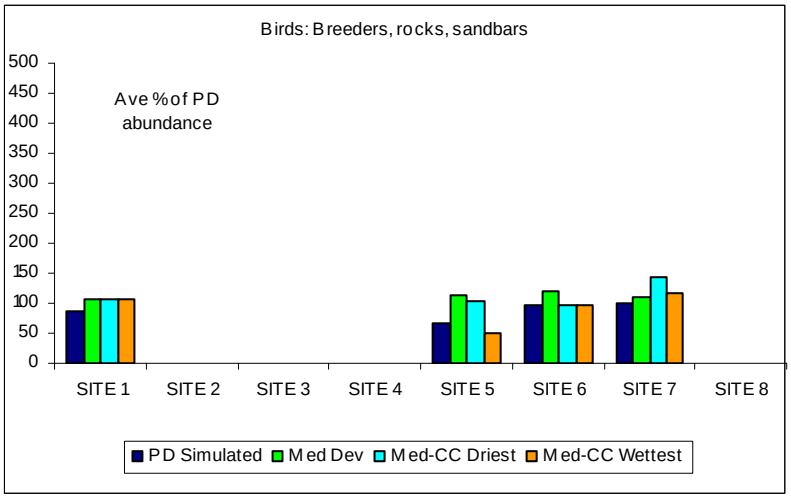


Site 8: Boteti River



Summary change per scenario

Low flow levels generally benefit these birds as this is the time when sandbanks and rocks are exposed for breeding. However, very low flows will result in sandbanks becoming accessible to predators and also negatively affect the food supply for those which eat fish (fish which need to get onto floodplains to breed).



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The Okavango River Basin Transboundary Diagnostic Analysis Technical Reports

In 1994, the three riparian countries of the Okavango River Basin – Angola, Botswana and Namibia – agreed to plan for collaborative management of the natural resources of the Okavango, forming the Permanent Okavango River Basin Water Commission (OKACOM). In 2003, with funding from the Global Environment Facility, OKACOM launched the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) Project to coordinate development and to anticipate and address threats to the river and the associated communities and environment. Implemented by the United Nations Development Program and executed by the United Nations Food and Agriculture Organization, the project produced the Transboundary Diagnostic Analysis to establish a base of available scientific evidence to guide future decision making. The study, created from inputs from multi-disciplinary teams in each country, with specialists in hydrology, hydraulics, channel form, water quality, vegetation, aquatic invertebrates, fish, birds, river-dependent terrestrial wildlife, resource economics and socio-cultural issues, was coordinated and managed by a group of specialists from the southern African region in 2008 and 2009.

The following specialist technical reports were produced as part of this process and form substantive background content for the Okavango River Basin Transboundary Diagnostic Analysis.

Final Study Reports	***Reports integrating findings from all country and background reports, and covering the entire basin.***		
		Aylward, B.	*Economic Valuation of Basin Resources: Final Report to EPSMO Project of the UN Food & Agriculture Organization as an Input to the Okavango River Basin Transboundary Diagnostic Analysis*
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		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment EFA Process Report (Report No: 02/2009)*
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		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions: Climate Change Scenarios (Volume 3 of 4) (Report No. 07/2009)*
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			Geomorfologia
		Gomes, Amândio	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Vegetação*
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		Livramento, Filomena	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina:Macroinvertebrados*
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Environmental protection and sustainable management of the Okavango River Basin

EPSMO

Boteti River shoreline, Botswana

Republic of Botswana

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