National Environmental Research Program

NORTHERN AUSTRALIA *hub*

NERP Theme 3: Aquatic Biodiversity Conservation

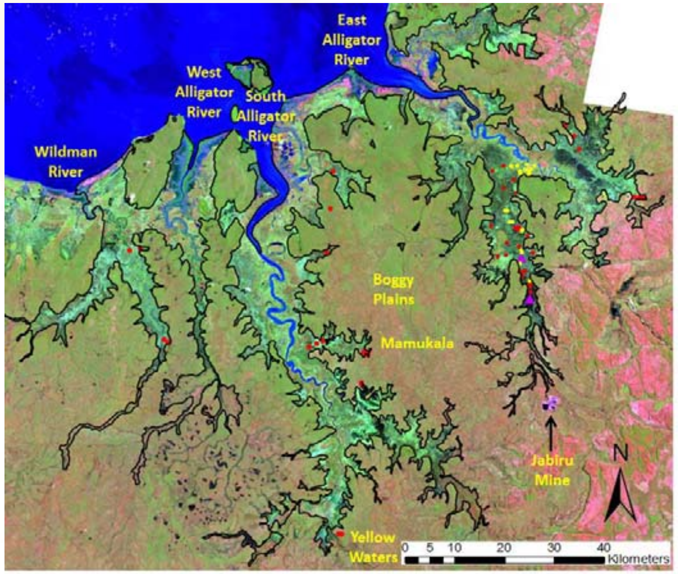
Project 3.1
River to landscape connections and biodiversity

Prof Stuart Bunn (GU), Dr. Brad Pusey (GU), Dr. Tim Jardine (U of Saskatchewan), Dr. Doug Ward (GU), Prof Brian Fry (GU), Prof Michael Douglas (CDU), Dr. Erica Garcia (CDU), Dr. Peter Kyne (CDU), Dr. David Crook (CDU/NT Fisheries), Dr. Allison King (CDU/NT Fisheries), Prof Peter Davies (UWA), Dr. Neil Pettit (UWA), Dr. Renee Bartolo (*eriss*)

River to landscape connections and biodiversity

AIMs:

- Understand the biological and physical linkages between rivers, floodplains and estuaries to allow prediction of how connectivity and flows affect aquatic biodiversity.



Research Location:

- Alligator Rivers Region

  (Kakadu National Park)

Key Project linkages:

- Kakadu National Park
  - Park Planning, and threat mamagement
  - Link KNP weeds team
- Project 3.2 (threats to floodplain biodiversity), 3.3 (freshwater biodiversity) and 3.4 (estuarine and coastal biodiversity)

River to landscape connections and biodiversity

RESEARCH COMPONENTS:

- **Floodplain inundation dynamics and connectivity**
  - Doug Ward, Aaron Petty, Samantha Setterfield, Renee Bartolo
- **Food web isotope analysis**
  - Stuart Bunn, Tm Jardine, Neil Pettit, Brian Fry, Dominic Valdez
- **Floodplain epiphytic algal productivity**
  - Neil Pettit, Doug Ward, Dominic Valdez, Fernanda Adame
- **Fish movement in the floodplains, and rivers**
  - Dave Crook and Pete Kyne

Timelines:

- **Project completion – <u>April 2015</u> (12 months left)**
  - **Floodplain LiDAR elevation data capture and compilation completed**
  - **Floodplain inundation dynamics completed**
  - **Food web, floodplain productivity and fish movement in final stages**

Floodplain inundation dynamics and connectivity

AIM:

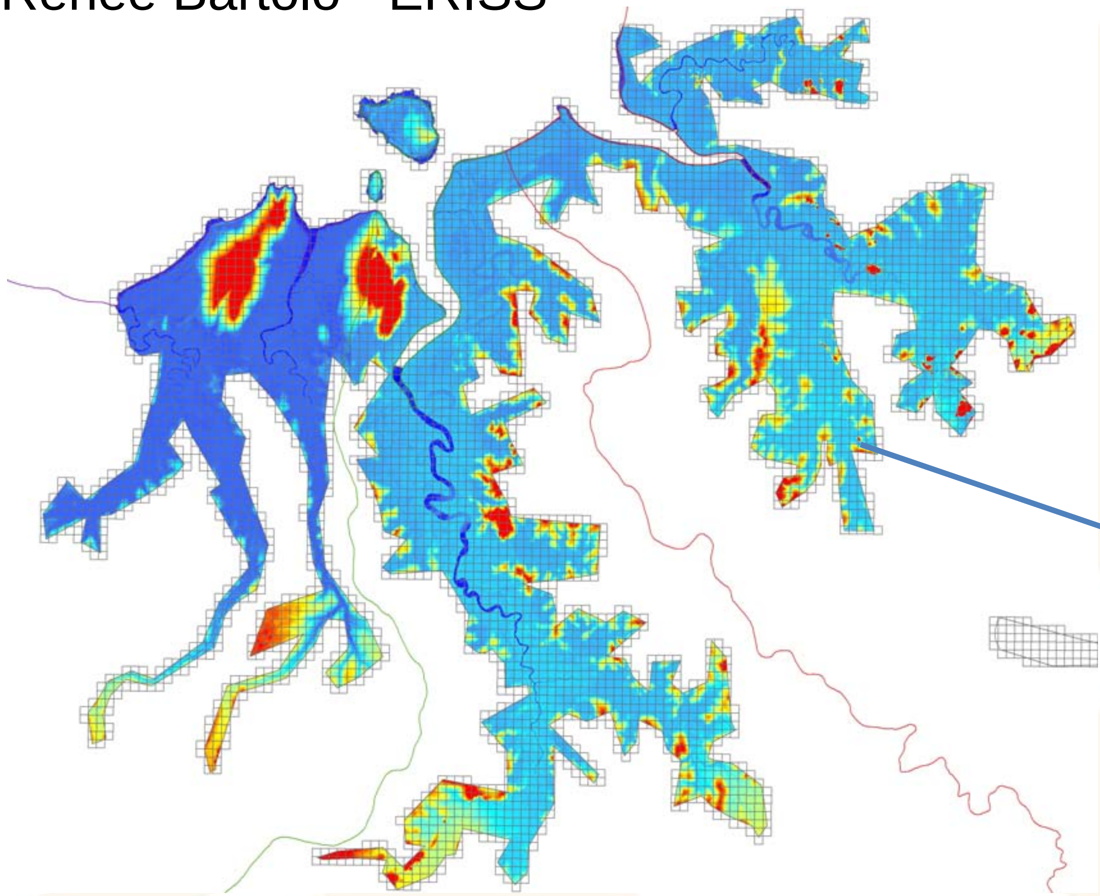
- Apply spatial technologies and remote sensing techniques to map inundation dynamics and connectivity

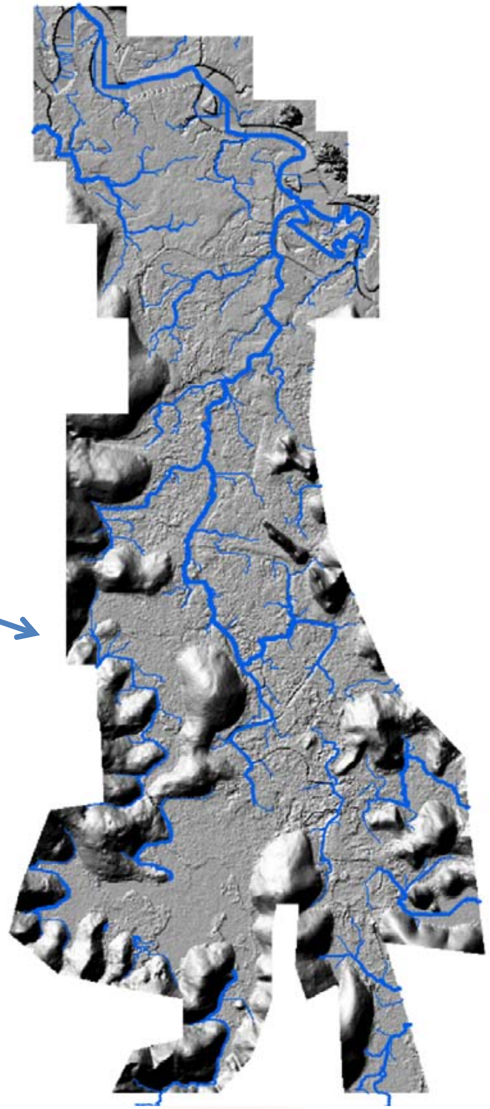
Project Components:

- Capture dry season LiDAR elevation data for the Kakadu floodplains (Renee Bartolo)
- Use satellite imagery to map spatial and temporal dynamics of floodplain inundation (Doug Ward)

Kakadu LiDAR elevation data

Renee Bartolo - ERISS





Applications:

- Modelling floodplain hydrodynamics
- Modelling salt water intrusion
- Mapping connectivity

Magela Creek Floodplain connectivity

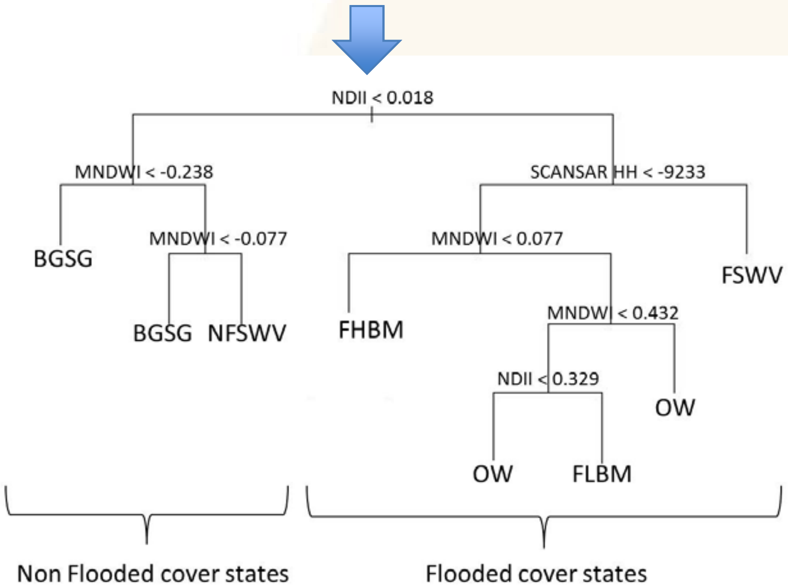
Mapping floodplain inundation dynamics using satellite imagery

Field survey data (A. Petty, S. Setterfield, others):

- Magela permanent vegetation survey plots (n=88)
- Magela water depth logger and iButton sites
- Wildman, West and south Alligator iButtons sites

Need to account for vegetation cover:

Floodplain cover state = F(Landsat IR indices, SCANSAR HH)



Decision tree model

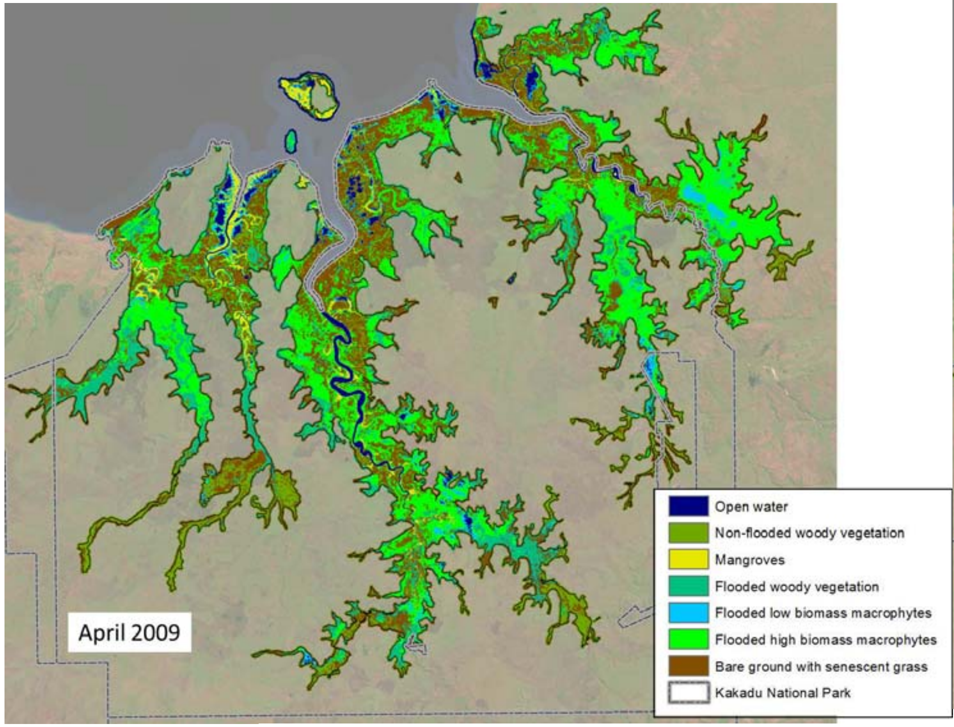
Modelled classes

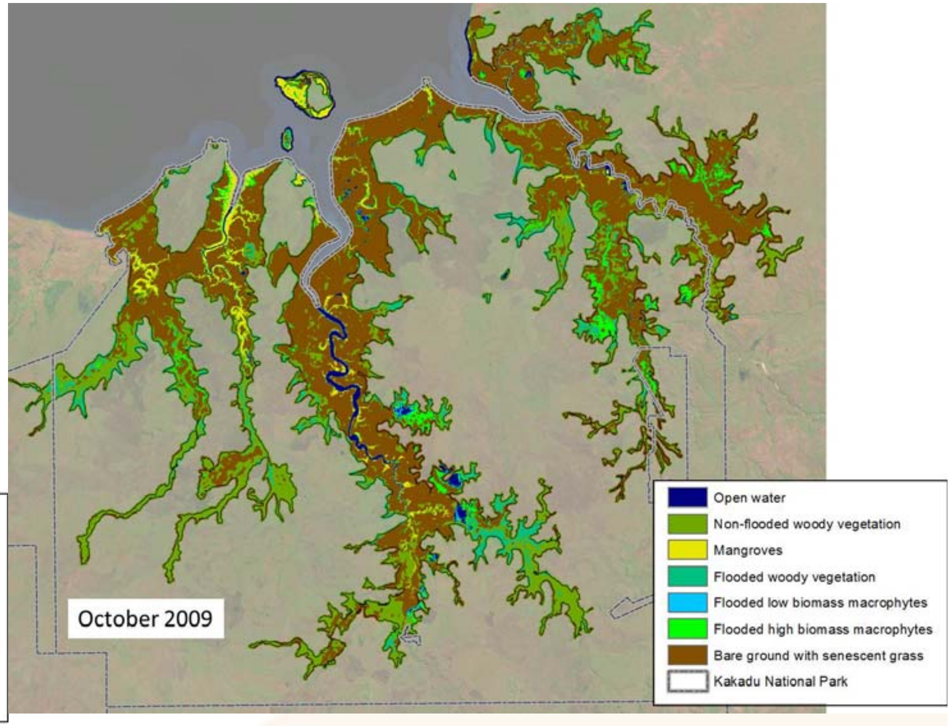
Code	Cover description	Code	Cover description
OW	Open water	FSWV	Flooded standing woody vegetation
FHBM	Flooded high biomass macrophytes	NSFWV	NonFlooded standing woody vegetation
FLBM	Flooded low biomass macrophytes	BGSG	Bare ground, senescent grass

Misclassification rate = 12%

NDII – consistent split between flooded and non flooded states

Floodplain vegetation dynamics



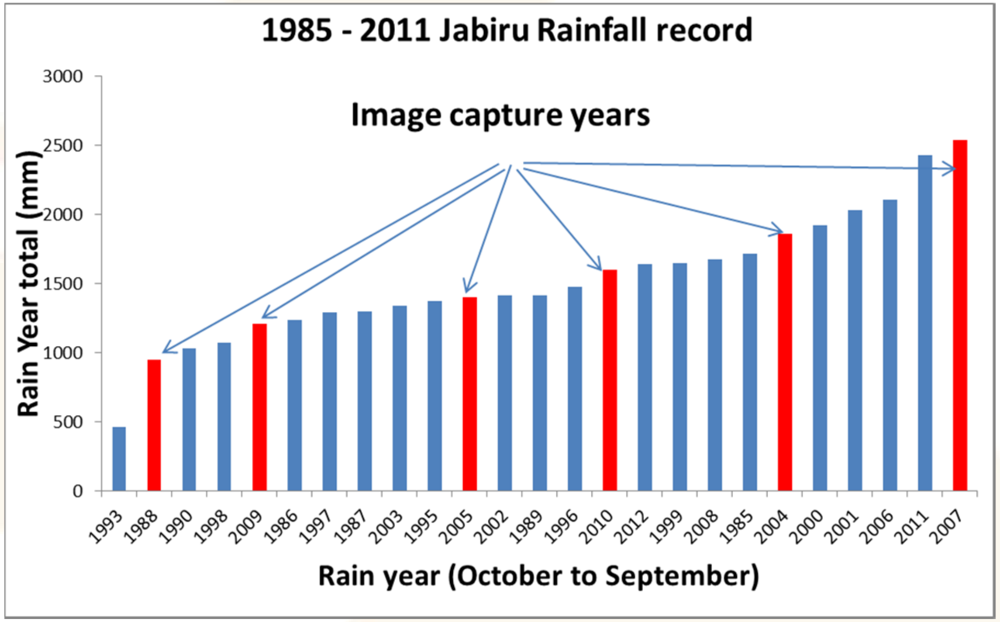


Code	Cover description	Code	Cover description
OW	Open water	FSWV	Flooded standing woody vegetation
FHBM	Emergent vertical species	NSFWV	NonFlooded standing woody vegetation
FLBM	Floating, submerged species	BGSG	Bare ground, senescent grass

Existing mangrove mapping was used to indicate extent of salt water intrusion

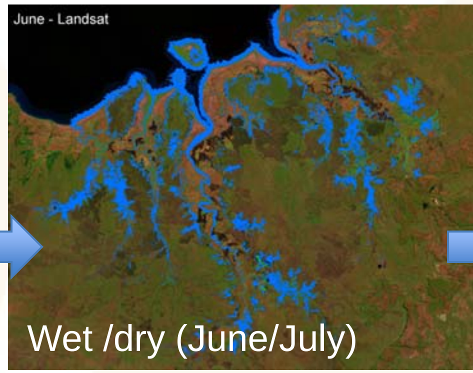
Kakadu floodplain inundation mapping

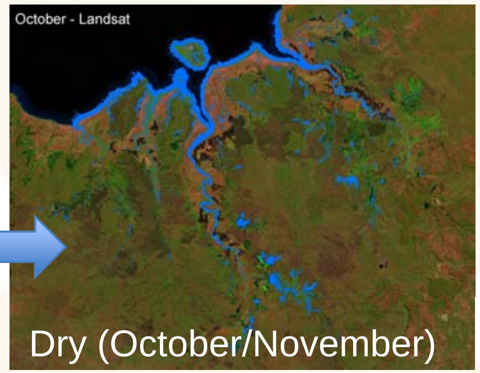
Seasonal inundation mapping based on 1985 to 2011 (26 yr) Landsat image archive



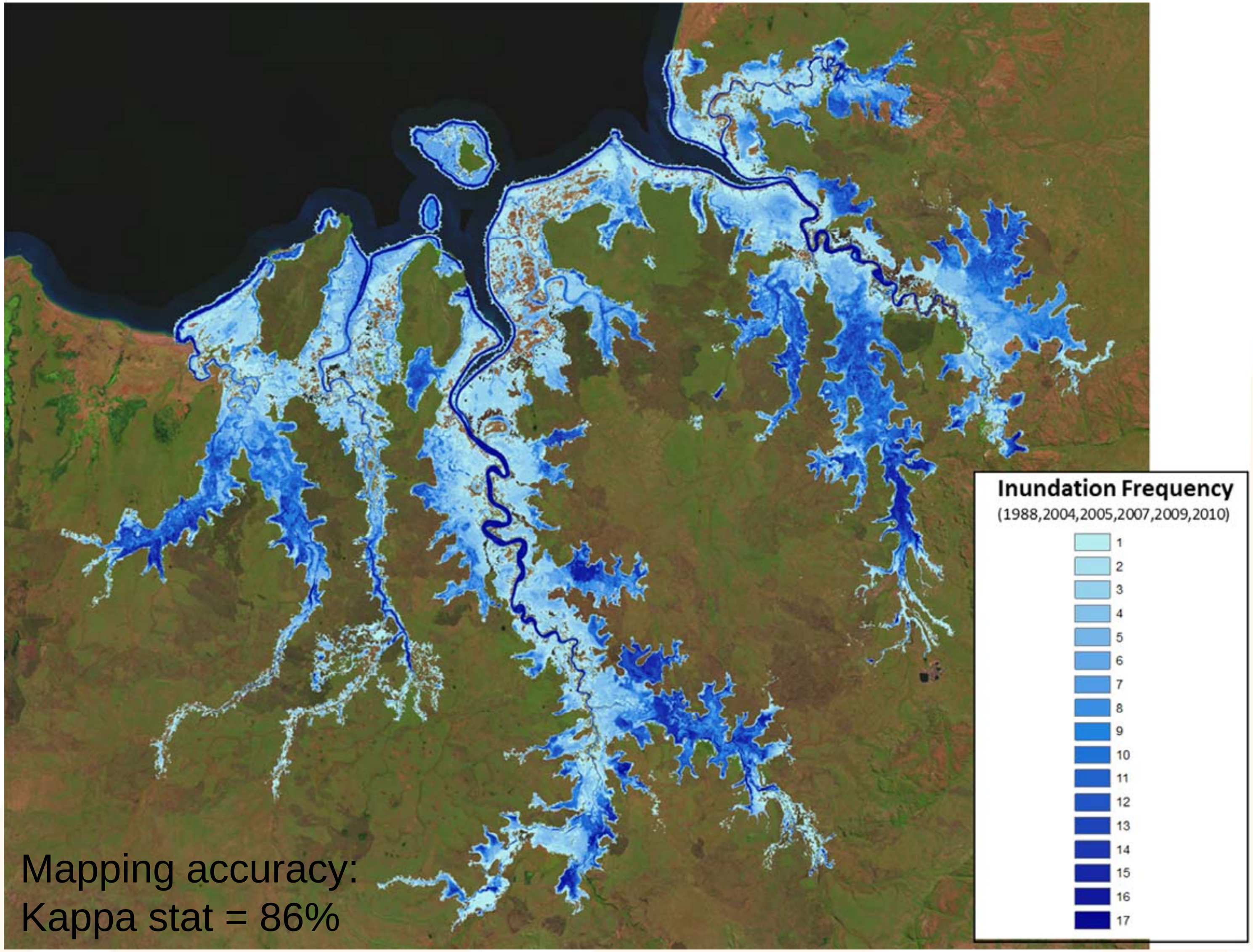
- Percentile analysis of rainfall record at Jabiru used to select years for image capture

3 image captures per year





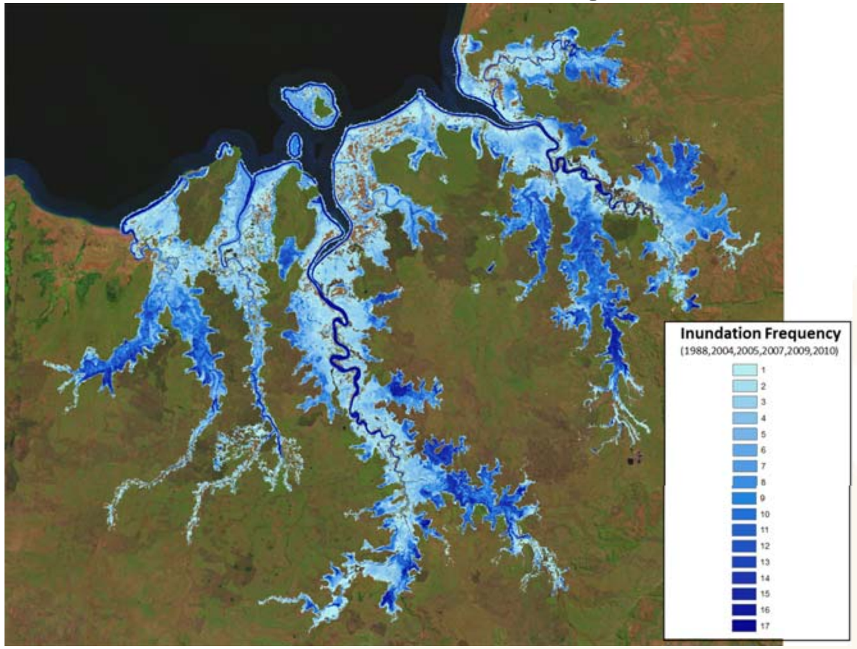
Kakadu Floodplain Inundation Frequency



Mapping accuracy:
Kappa stat = 86%

25 yr Inundation frequency - surrogate for inundation duration

Kakadu Floodplain inundation dynamics



ELSEVIER

Remote Sensing of Environment

Volume 147, 5 May 2014, Pages 43–55

Floodplain inundation and vegetation dynamics in the Alligator Rivers region (Kakadu) of northern Australia assessed using optical and radar remote sensing

D.P. Ward[a], A. Petty[b], S.A. Setterfield[b], M.M. Douglas[b], K. Ferdinands[c], S.K. Hamilton[d], S. Phinn[e]

Kakadu Floodplain inundation product made available to NERP researchers but not publically available as yet

APPLICATIONS:

- Habitat suitability mapping for weed spread
- Assessment of aquatic connectivity for fish and croc movement
- Calibration of hydrodynamic models
- Assessment of salt water intrusion
- Aquatic vegetation mapping

River, floodplain food web dynamics

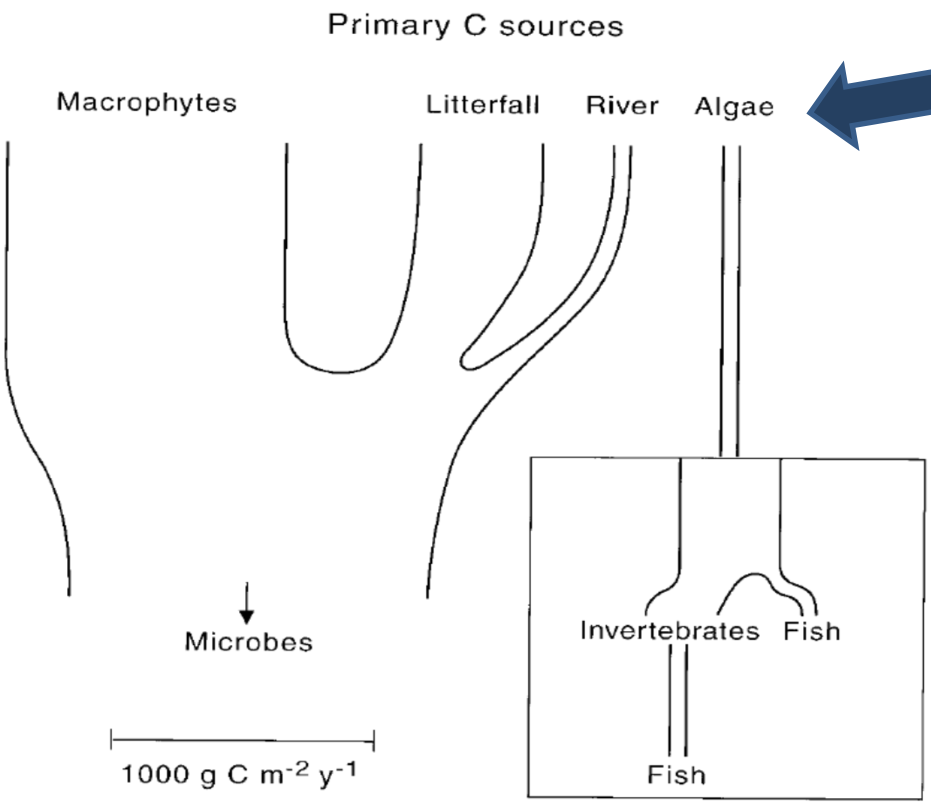
AIM:

- Understanding the food web linkages between rivers, floodplain and the estuary

Project Components:

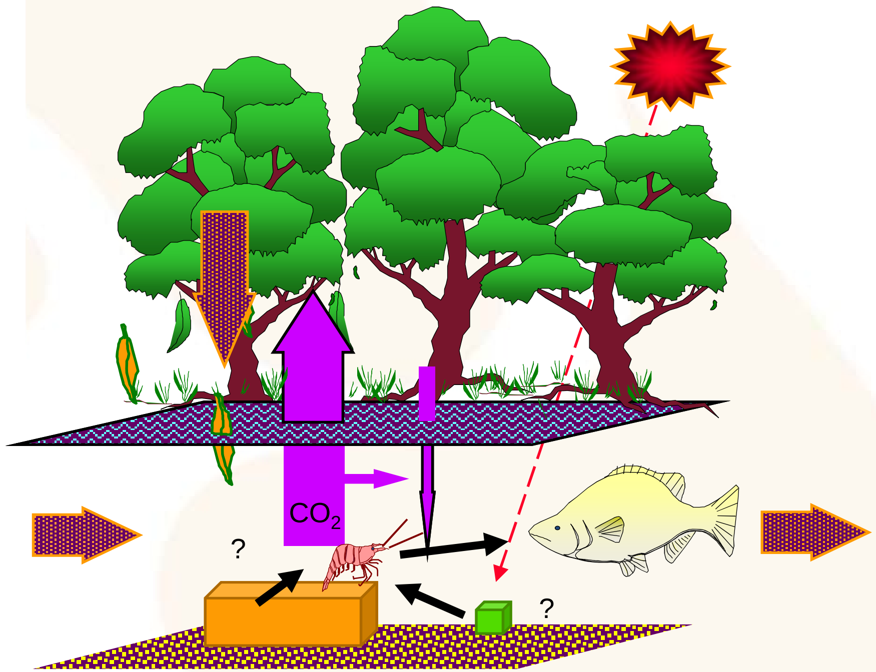
- Use stable isotopes analysis to understand the spatial and temporal linkages between producers and consumers
- Quantify food web subsides across aquatic and terrestrial habitats
- Quantifying the importance of floodplain subsides to reproduction (Fransico Villamarin PhD student).

Importance of algae in aquatic food webs



Lewis et al. (2001)

Where are hotspots?
What are key drivers?



Heterotrophic ecosystems … but often epiphyte dependent food webs

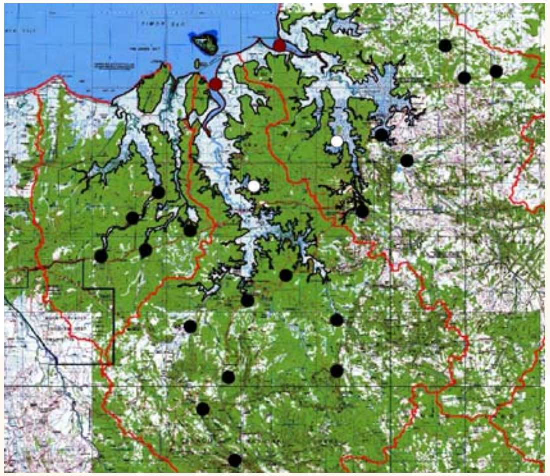
Food web isotope analysis

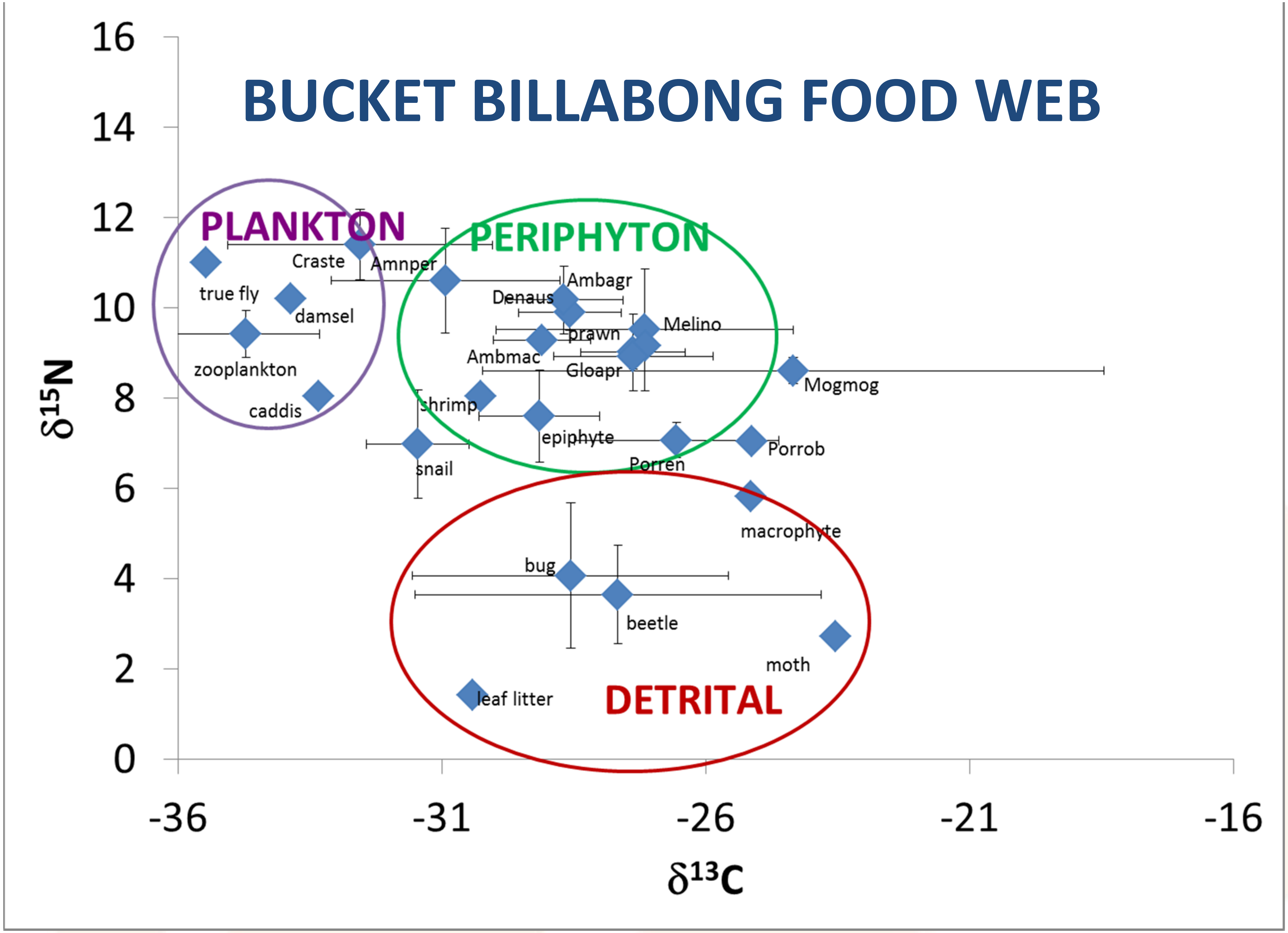
Sampling

- Producers and consumers
  - Producers e.g. algae, leaf litter, plankton
  - Small animals e.g. insects, prawns, fish
  - Large animals e.g. crocodiles, magpie geese, turtles, kanagroo, pigs
- Reproductive components
  - Crocodile eggs, magpie geese eggs, fish gonads (RNA/DNA analysis)

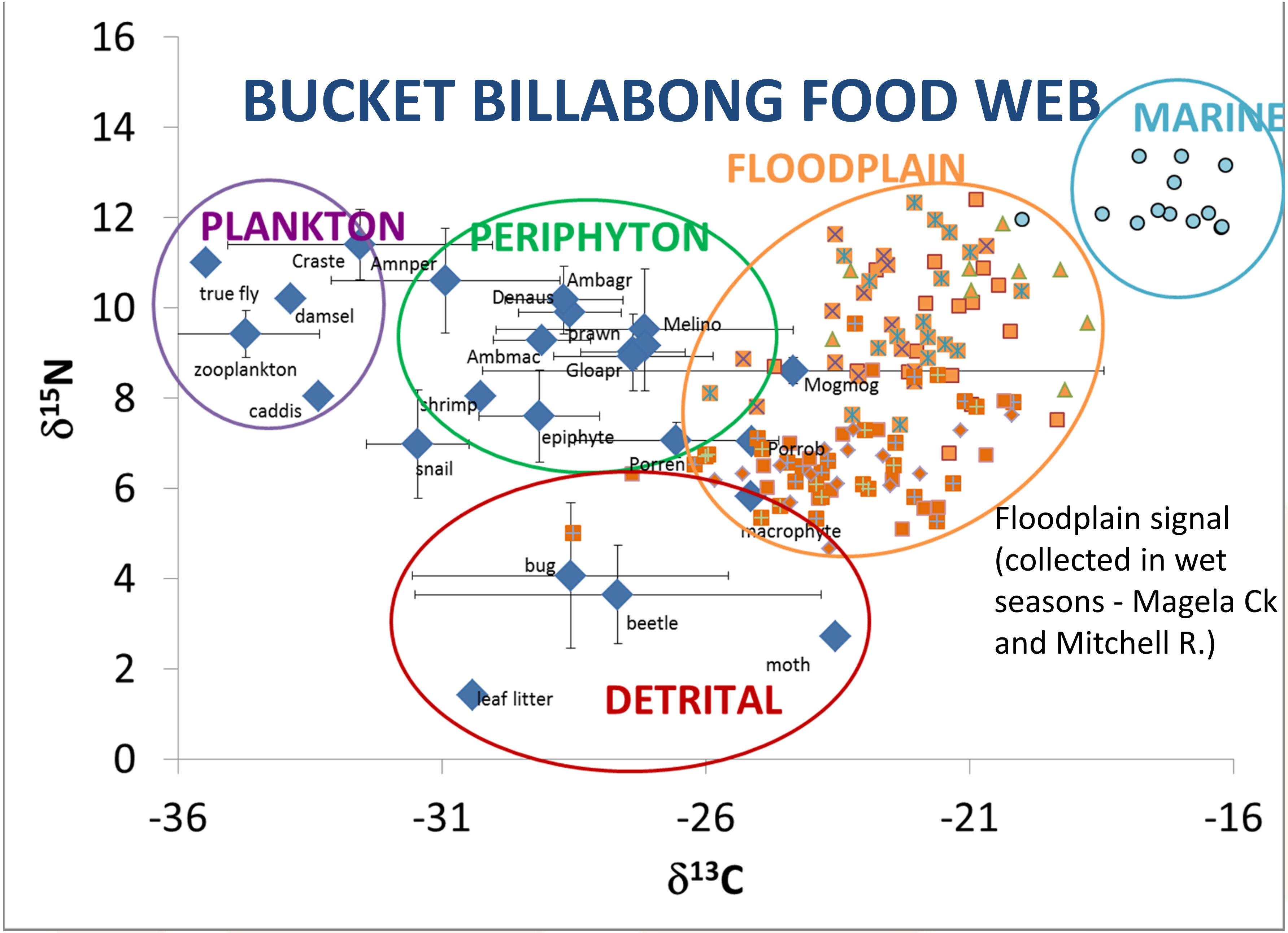
Sample locations

- Upper catchment
- Floodplain
- Estuary

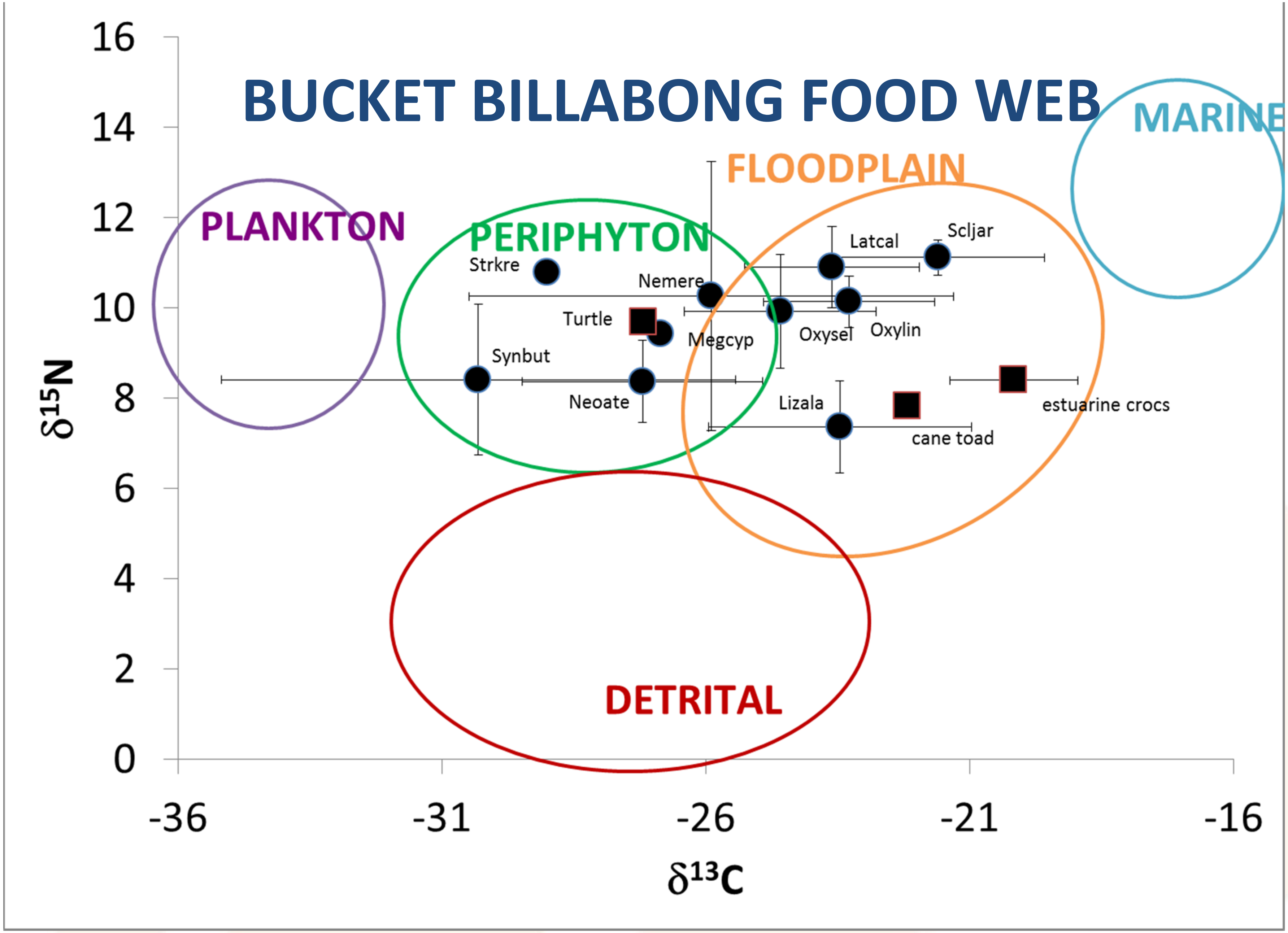




Small fish and invertebrates dependent on three different source pathways

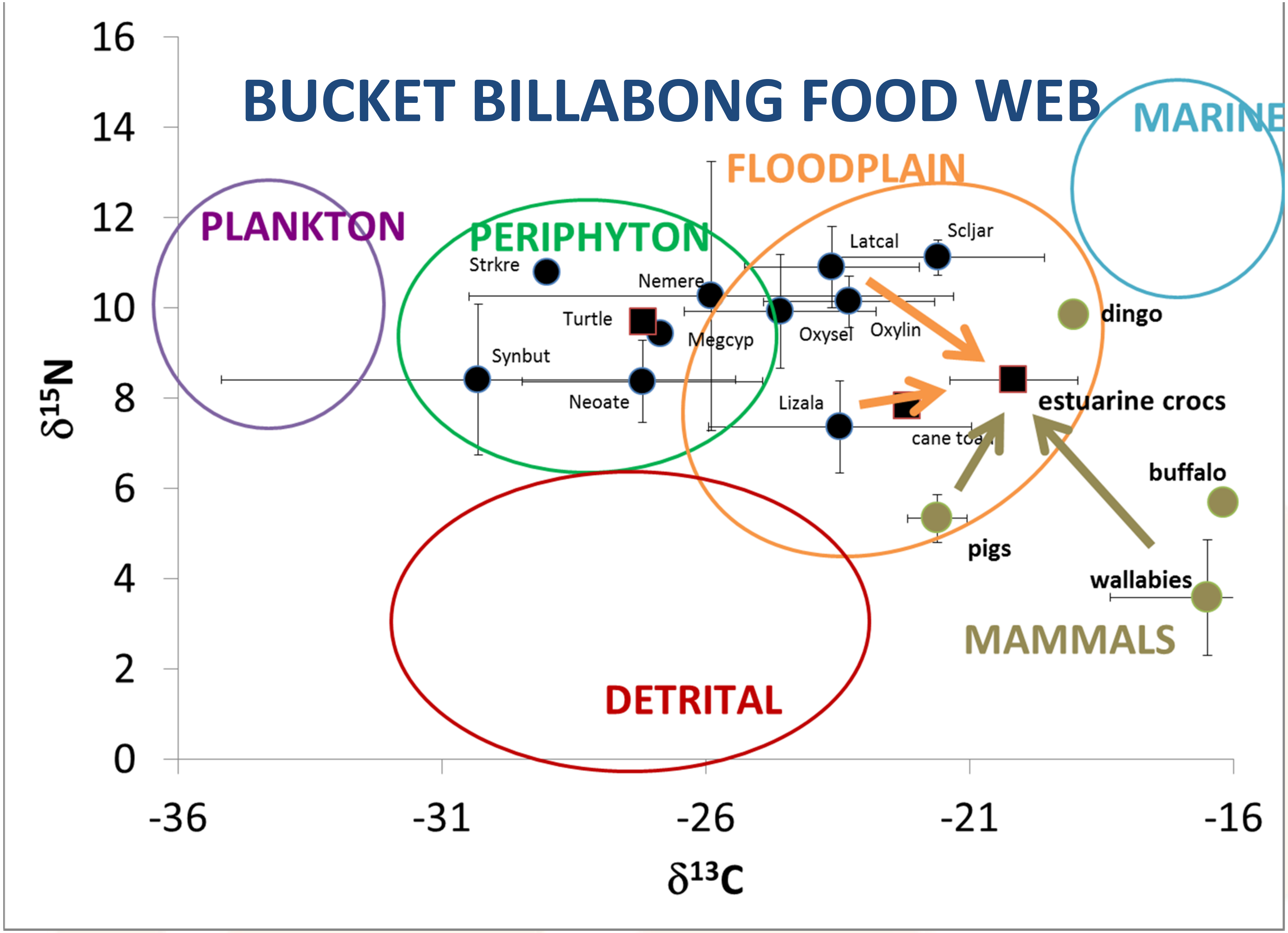


Other sources are available to larger, more mobile animals

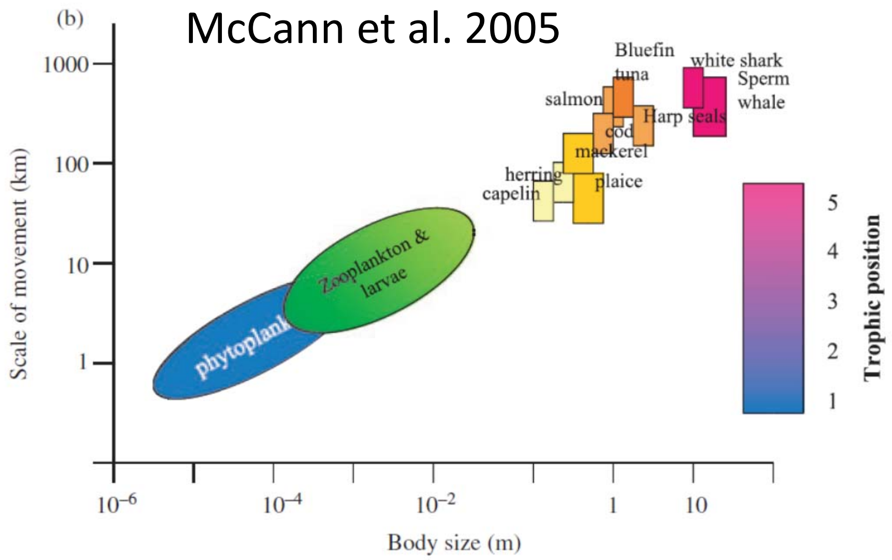


Large animals derive energy from high quality algae and the floodplain

Crocs largely disconnected from local food web – what else are they eating?



Samples collected by Parks staff and TOs show that mammals from the surrounding savanna make up a large part of the croc diet. We can calculate just how much. Crocodiles obtain on average only 19% (+/- 16%) of their diet from within the waterhole. We now have data for 13 individuals from 4 sites (more to come).



Size and subsidies

- Two pathways
- Higher mobility of larger animals
- Exploitation of prey during visits or return
  - The waterholes are generally not productive enough to keep the big animals going
  - The only way some of these larger animals (e.g. crocs, barra) can be sustained is via seasonal connectivity.

Floodplain epiphyte production

AIM:

- Quantify the importance of different habitats in sustaining fish and other consumers in river-floodplain systems

Project Components:

- Dark bottle/light bottle and ^{13}C incubation experiments to measure epiphyte productivity
- Quantify the relationship between epiphyte abundance and marcophyte structural types
- Map the seasonal spatio-temporal variability of epiphyte productivity on the floodplain

Floodplain epiphyte productivity

Epiphyton and phytoplankton primary production:

^{13}C incubation experiments

Dark / Light bottle expirements

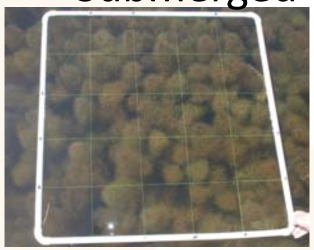
Treatments: Macrophytes + epiphyton, Epiphyton, and Macrophytes

Light levels: Light, 70% and dark (^{13}C experiments)

Structural types sampled:

Open water

Submerged

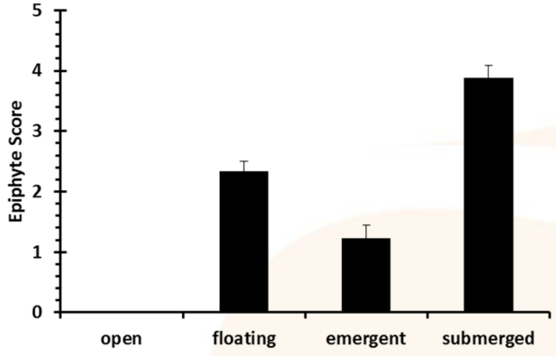


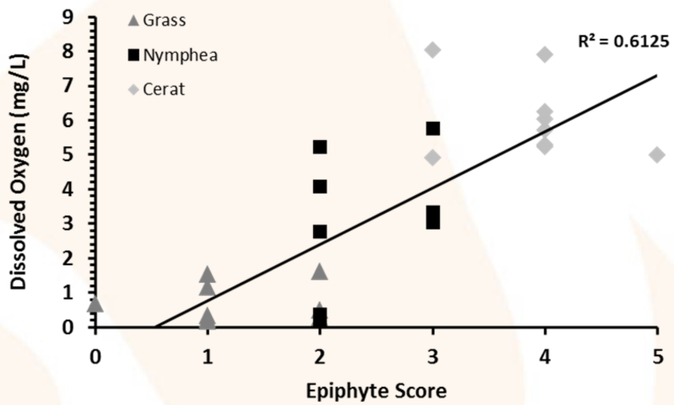
Floating

Emergent

Floodplain epiphyte production

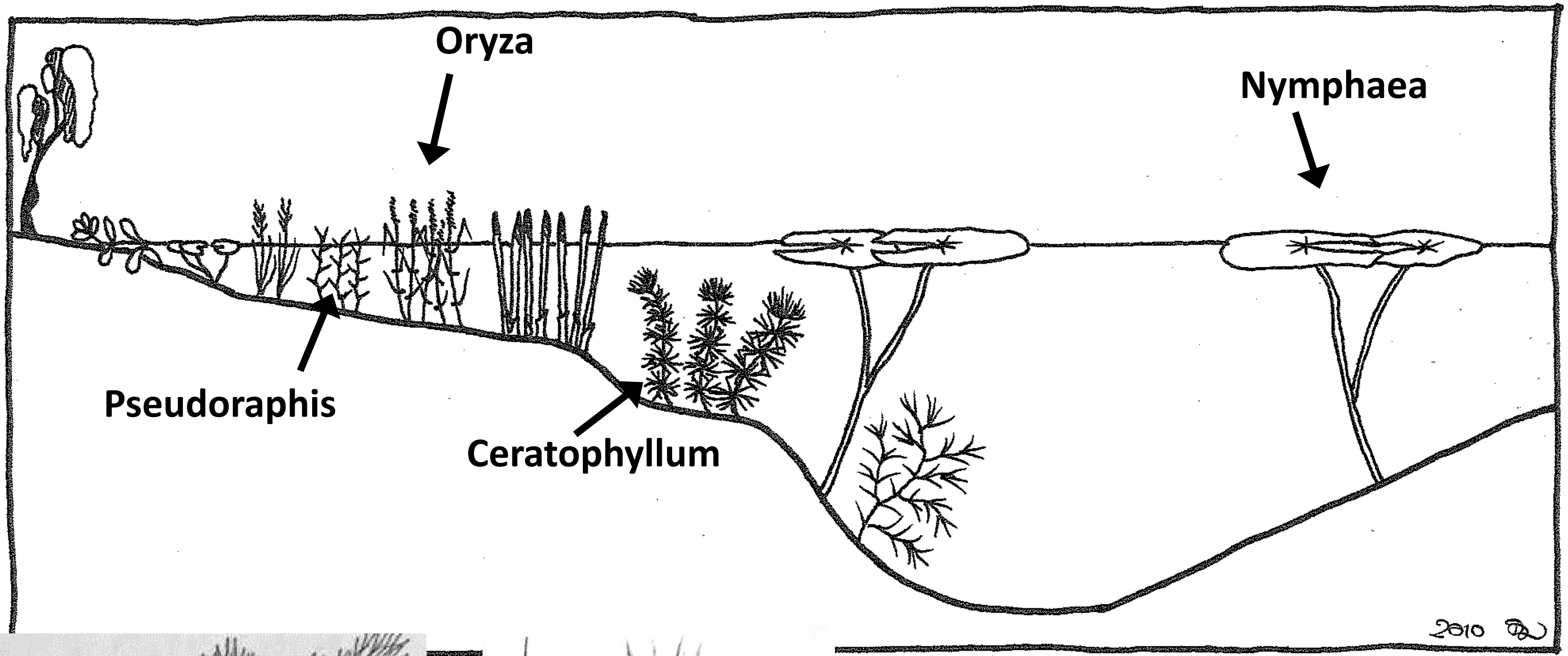
- Relationship between epiphytic algae abundance and marcophyte structural types

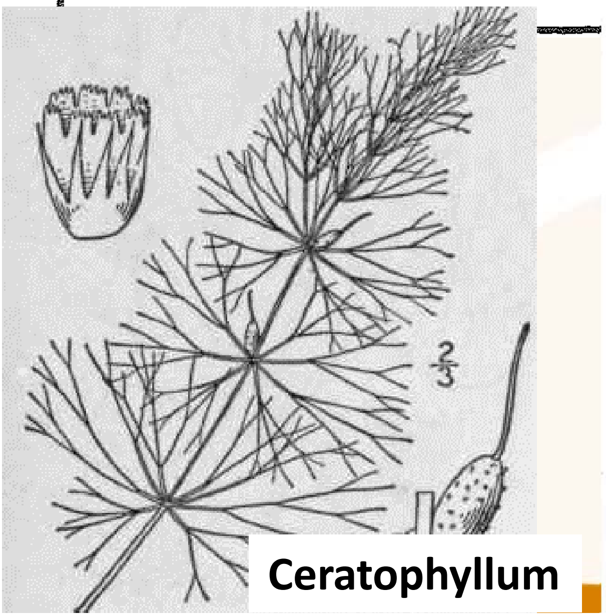


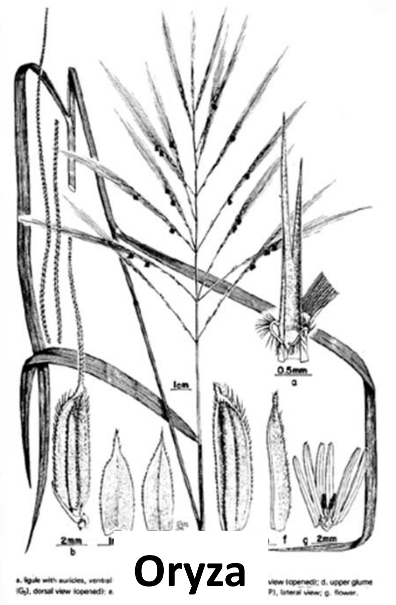


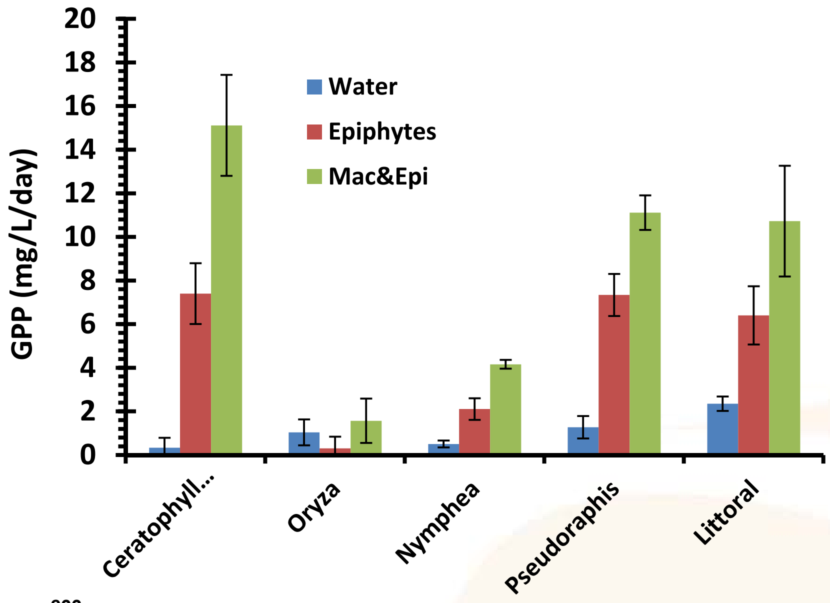
- Measurements of macrophyte structure to characterize capacity to support epiphyton

Differences in plant architecture

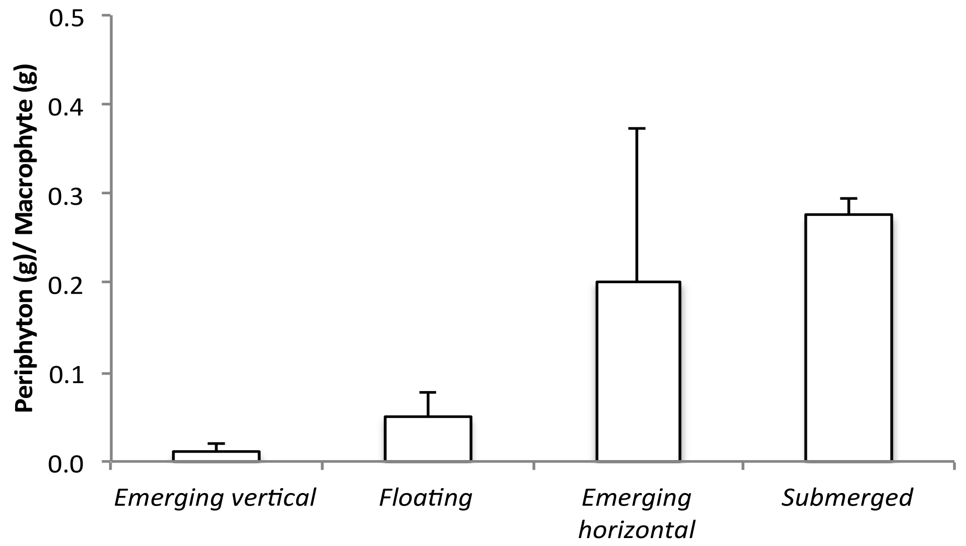




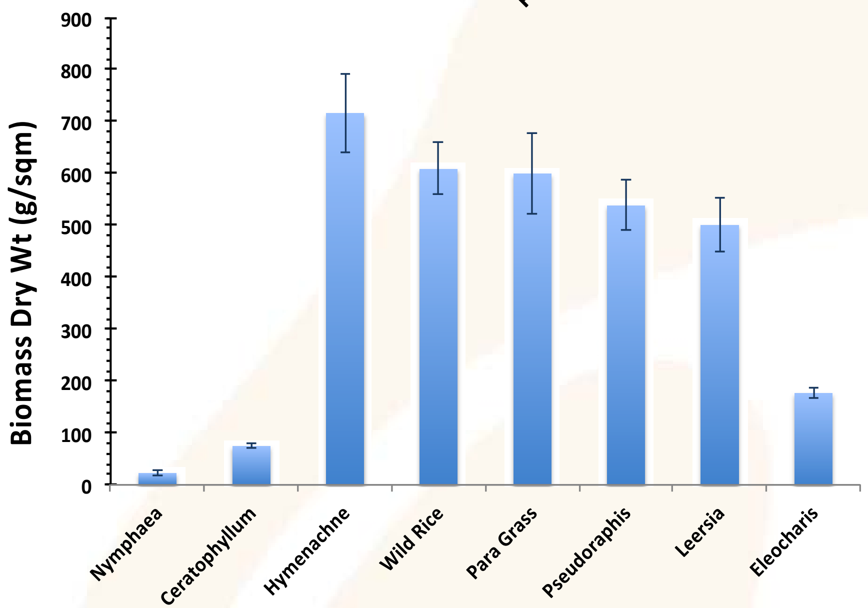




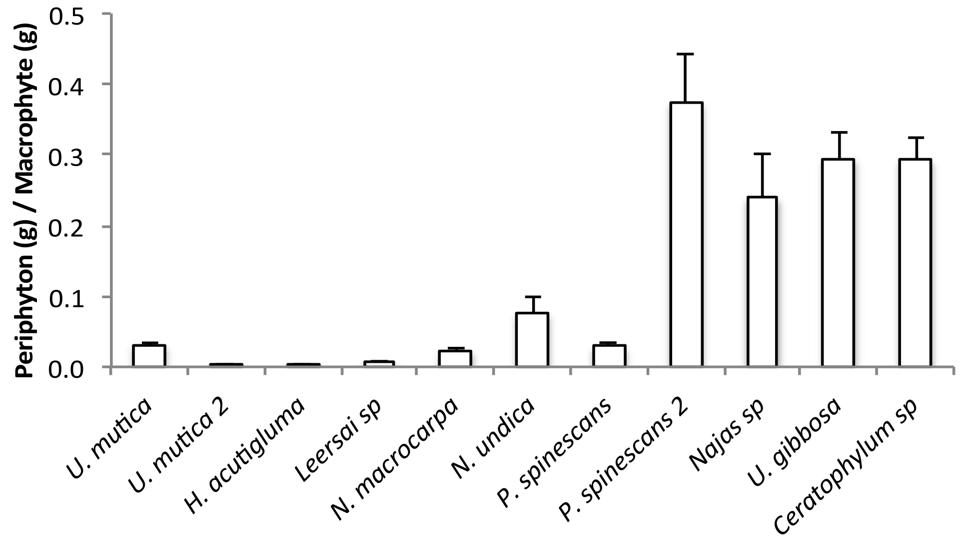
GPP (mg/L/day)
20
18
16
14
12
10
8
6
4
2
0
Water
Epiphytes
Mac&Epi
Ceratophyll...
Oryza
Nymphea
Pseudoraphis
Littoral



Periphyton (g)/ Macrophyte (g)
0.5
0.4
0.3
0.2
0.1
0.0
Emerging vertical
Floating
Emerging horizontal
Submerged



Biomass Dry Wt (g/sqm)
900
800
700
600
500
400
300
200
100
0
Nymphaea
Ceratophyllum
Hymenachne
Wild Rice
Para Grass
Pseudoraphis
Leersia
Eleocharis



Periphyton (g) / Macrophyte (g)
0.5
0.4
0.3
0.2
0.1
0.0
U. mutica
U. mutica 2
H. acutiglume
Leersai sp
N. macrocarpa
N. undica
P. spinescans
P. spinescans 2
Najas sp
U. gibbosa
Ceratophylum sp

Aquatic primary production very patchy on the floodplain

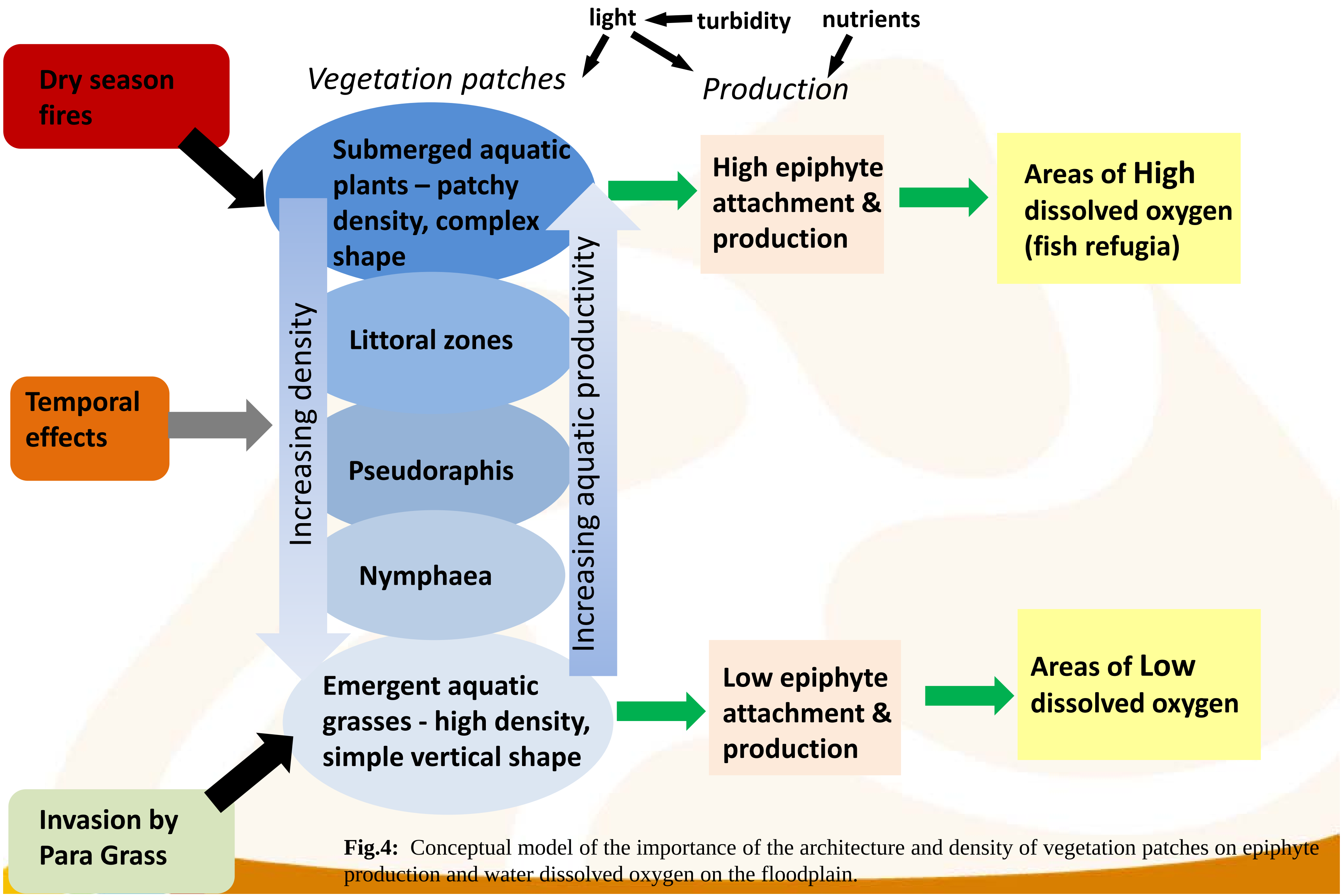
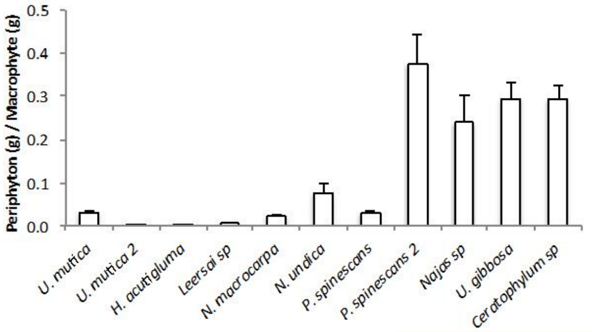


Fig.4: Conceptual model of the importance of the architecture and density of vegetation patches on epiphyte production and water dissolved oxygen on the floodplain.

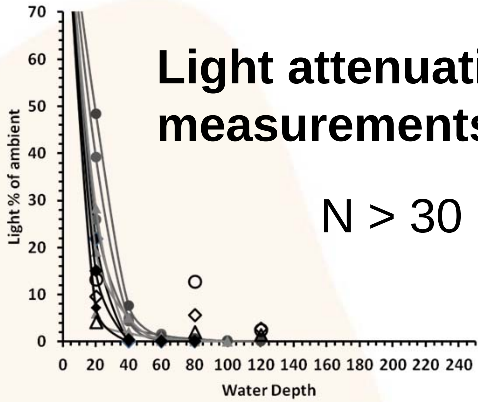
Map the seasonal dynamics of floodplain epiphyte production

epiphyte biomass x veg type

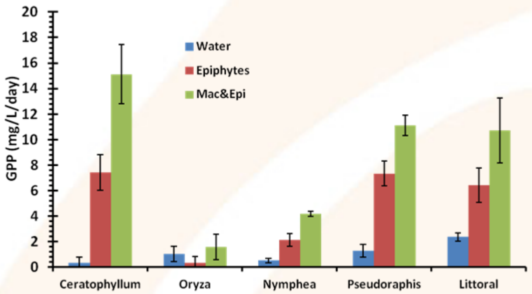


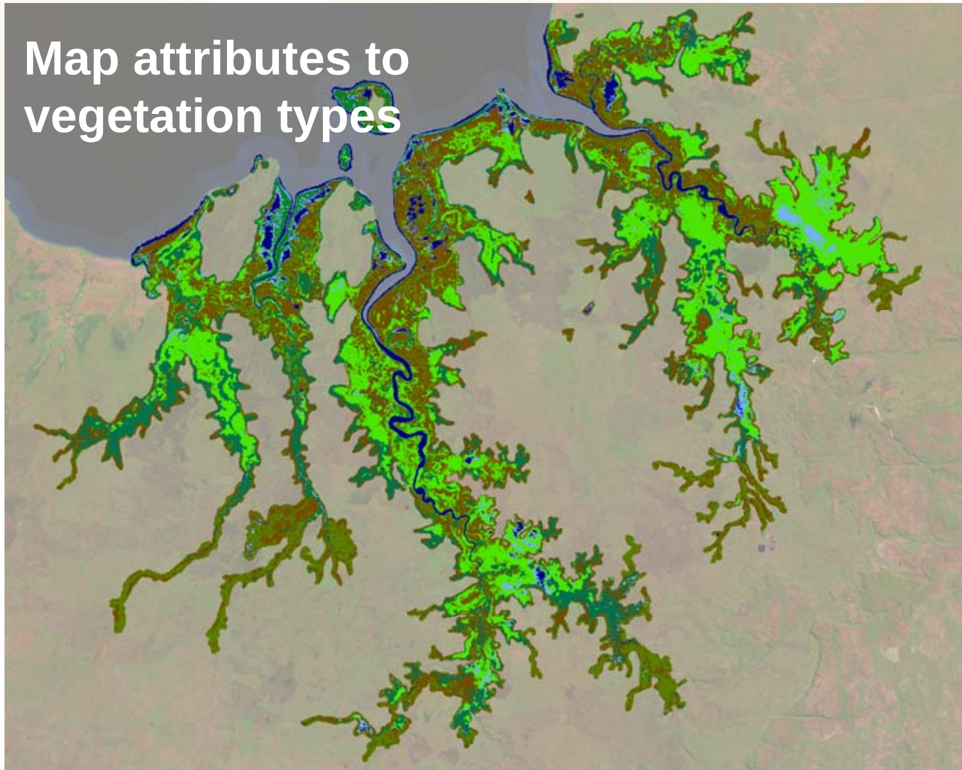
Light attenuation measurements

N > 30

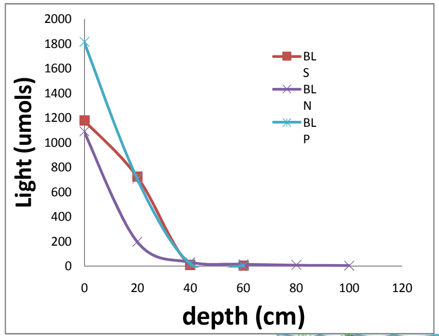


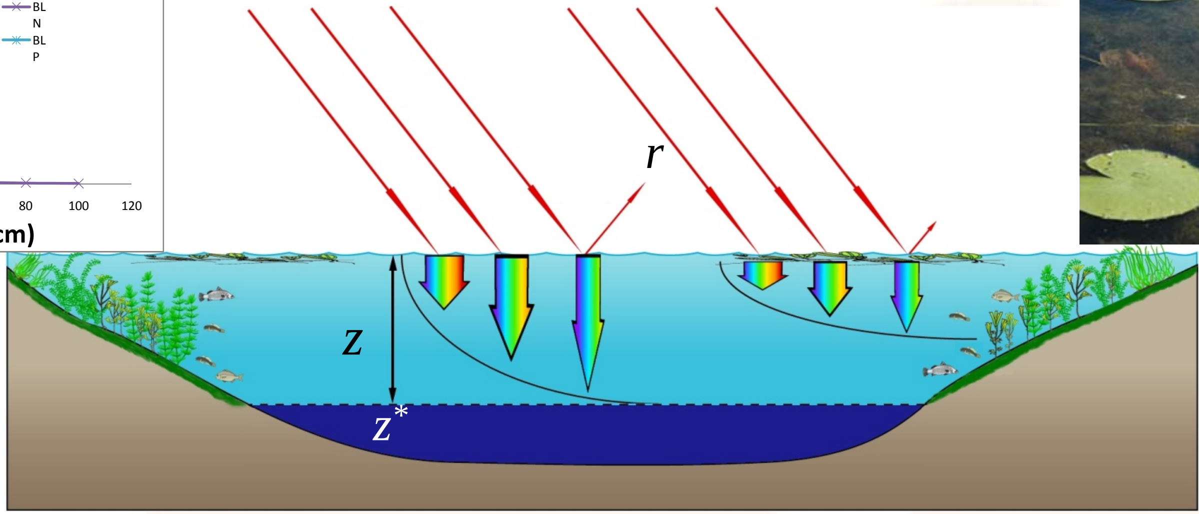
Primary production





Spatial floodplain light model





Macrophyte cover C_p reduces the amount of incoming solar radiation and is incorporated in PAR as

$$PAR = -\frac{\phi}{k} I_0 \left(e^{-kz} - 1\right)$$

Beer-Lambert law
(PAR integrated over depth)

where

$$\phi = 1 - C_p$$

and

C_p – is the macrophyte cover proportion

Light model parameters

$$PAR = -\frac{\phi}{k} I_0 \left(e^{-kz} - 1\right)$$

Aquatic surface cover (C_p):

- Predict cover from regression relationship between field measurements of macrophyte cover and NDVI ($R^2 = 0.85$)

Water depth (z):

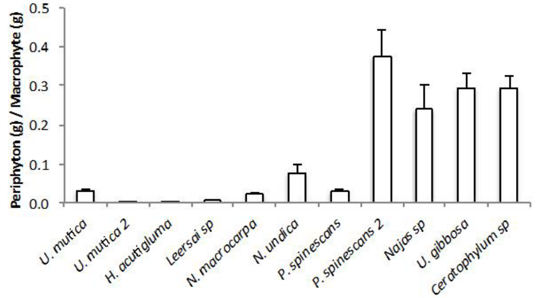
- Use flood extent mapping to get water depth from LiDAR data on floodplain edge
- Interpolate water surface elevation over flood extent

Light attenuation coefficient (K_d):

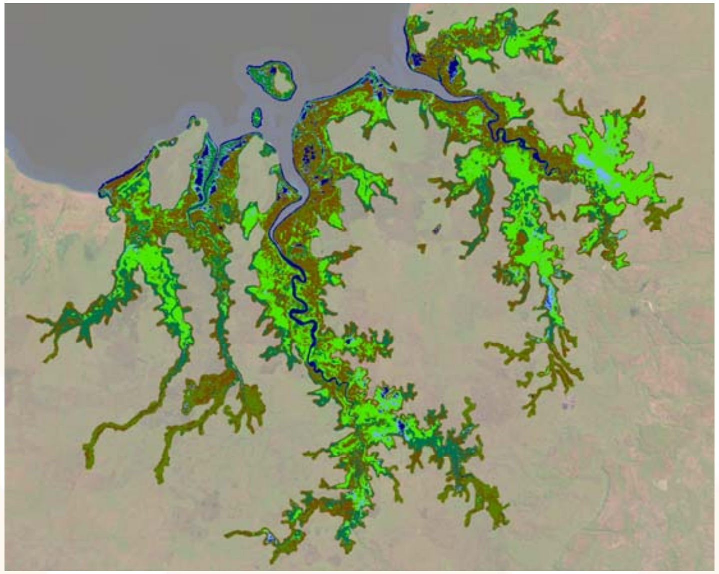
- Predict Kd from predicted turbidity (Landsat based turbidity model)
- Estimate Kd for all deep billabongs, channels and open water areas (very little macrophyte cover)
- Interpolate Kd between open water estimates of Kd

Spatial quantification of epiphytic production

Field based measurements



Epiphyte biomass per unit area by vegetation type

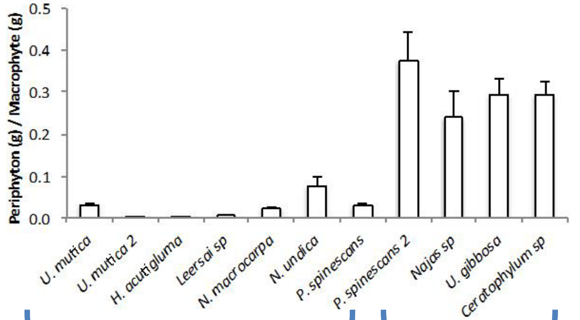


Spatial interpolation of epiphyte biomass:

- Attribute epiphyte biomass by vegetation type to CSIRO floodplain vegetation mapping
- Model epiphyte biomass using site measurements
  - Epiphyte biomass = F(SCANSAR, NDII, CSIRO Veg)

Seasonal dynamics of epiphytic production

Epiphyte biomass per unit area by vegetation type



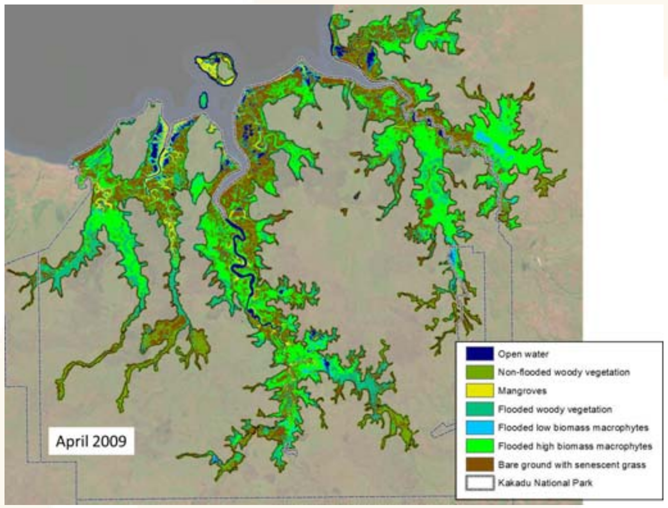
Emergent vertical species

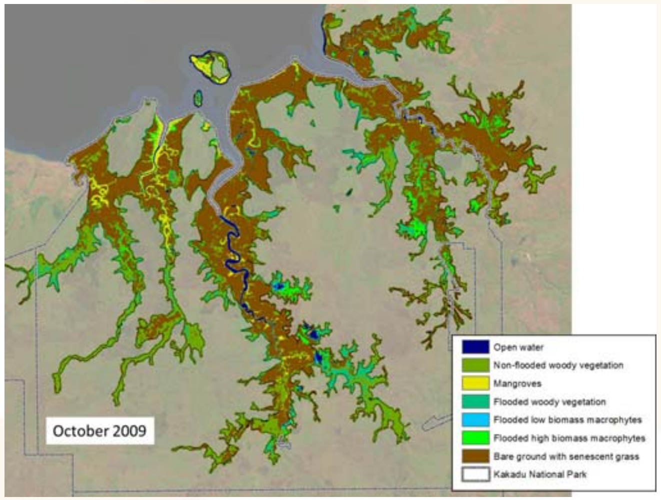
Floating, submerged and emergent horizontal species

Modelled floodplain cover states

Code	Cover description	Code	Cover description
OW	Open water	FSWV	Flooded standing woody vegetation
FHBM	Emergent vertical species	NSFWV	NonFlooded standing woody vegetation
FLBM	Floating, submerged species	BGSG	Bare ground, senescent grass

Temporal variability in floodplain epiphytic production using modelled cover states



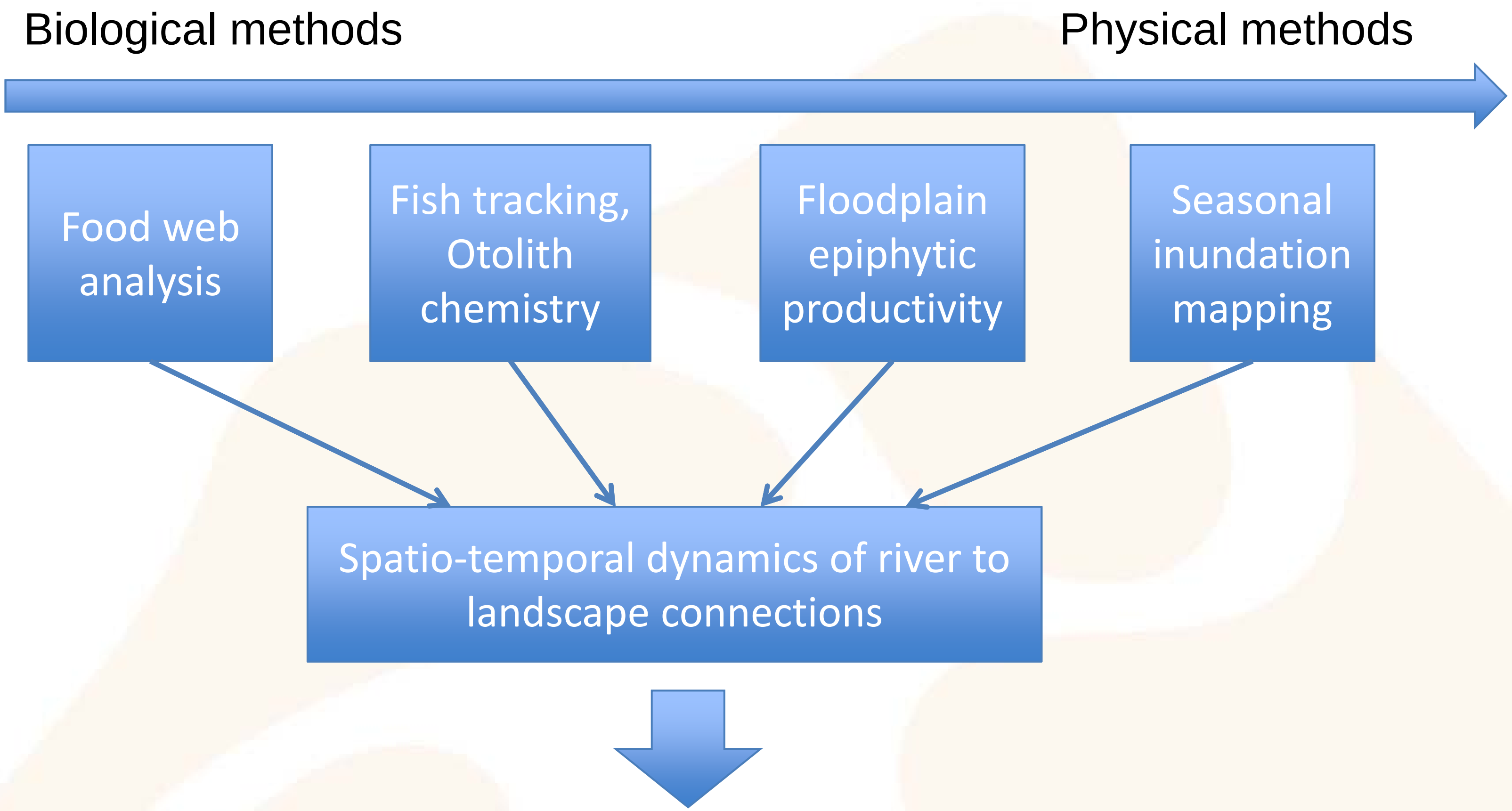


River to landscape connections and biodiversity

SUMMARY (preliminary findings):

- **Floodplain inundation dynamics and connectivity**
  - **Spatial Products:**
    - LiDAR elevation data
    - Floodplain inundation frequency
- **Food web isotope analysis**
  - The waterholes not productive enough to keep the big animals going
  - The only way some of these larger animals (e.g. crocs, barra) can be sustained is via seasonal connectivity
- **Floodplain epiphyitic productivity**
  - Epiphyte production 3 to 4 times greater in submerged macrophytes
  - Macrophyte architecture is a major determinant of epiphyte production
  - Light availability is a major driver in epiphyte production
  - Epiphyte spatio-temporal dynamics ???????

Integration



- Global floodplain ecology
- Kakadu Park management
- Policy and planning

Acknowledgements

Kakadu National Park Rangers

Calvin Murakami

Fred Hunter