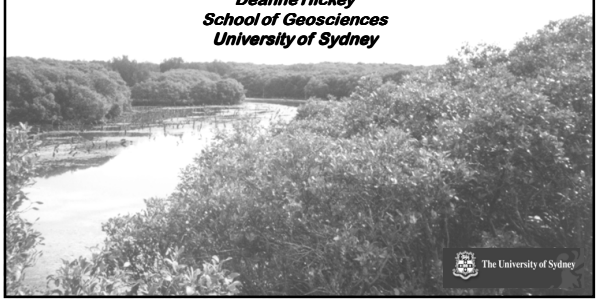
# Groundwater influences upon vegetative structure in a coastal wetland environment

***Deanne Hickey***
***School of Geosciences***
***University of Sydney***




## Coastal Wetlands

*Provide a vital habitat for intertidal organisms including…*

• Birds, fish, crustacean, molluscs and annelids

• Provide a protective barrier against ecological, oceanic and atmospheric processes

• Manage estuarine processes including sedimentation and nutrient enrichment

(Source: West, 1985; Hutchings & Saenger, 1987; Adam, 1994; Harty, 1997; Mazmuder *et al.*, 2006)

## Coastal Wetlands

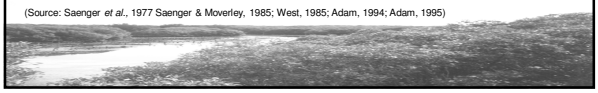
*In Australia mangrove and saltmarsh habitats are found throughout temperate and tropical regions*

• Saltmarsh habitats are generally associated with seaward mangrove vegetation

• Species richness of mangrove habitats generally decreases with increasing latitude

• Species richness of saltmarsh habitats generally increases with increasing latitude

(Source: Saenger *et al.*, 1977 Saenger & Moverley, 1985; West, 1985; Adam, 1994; Adam, 1995)



## Vegetation Distribution

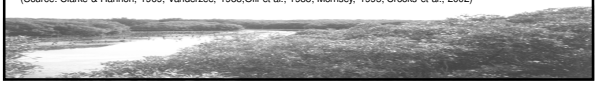
*Tidal inundation is the primary factor determining vegetation distribution*

• Surface elevation influences tidal inundation extent, duration & frequency

  • This relationship between surface elevation and tidal inundation controls factors influential in determining species distribution & include;

    • waterlogging
    • salinity
    • soil aeration
    • sedimentation
    • propagule dispersion

(Source: Clarke & Hannon, 1969; Vanderzee, 1988;Olff et al., 1988; Morrisey, 1995; Crooks et al., 2002)



## Habitat Loss

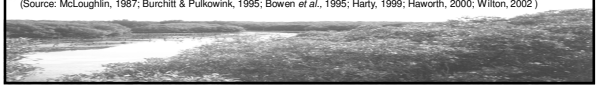
*Mangrove and saltmarsh habitats are vulnerable to human disturbances…*

• Changes in mangrove and saltmarsh habitats have been attributed to;

  • urban run off containing heavy metals & excess nutrients
  • industry production
  • engineering works & urban and rural development
  • estuary development
  • oyster farming, agriculture and horticulture

• In NSW alone, over 60% of coastal saltmarsh has been lost or degraded since European settlement

(Source: McLoughlin, 1987; Burchitt & Pulkowink, 1995; Bowen *et al.*, 1995; Harty, 1999; Haworth, 2000; Wilton, 2002 )



## Mangrove Encroachment

*Changes in saltmarsh distribution have also been attributed to mangrove encroachment…*

• Encroachment may result from human disturbance or natural occurrence including;

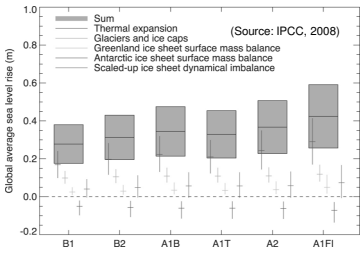
  • Increased rainfall
  • Nutrient enrichment
  • Sea level rise and subsidence
  • Sedimentation – sea level dynamics

(Source: McLoughlin, 1987; Saintilan & Hashimoto, 1999; Saintilan & Williams, 1999; Saintilan & Wilton, 2001)

## Sea Level Rise

*The position of mangrove and saltmarsh habitats within the intertidal area makes them vulnerable to sea level rise…*

• IPCC estimates global sea level will rise between 0.18m & 0.59m by 2100




## Sea Level Rise

*The response a wetland system exhibits to sea level rise is dependent upon various factors including;*

- sedimentation
- subsidence
- tidal regime
- vegetation

*The relationship between the net sedimentation rate & the rate of relative sea level rise will determine the action a wetland system demonstrates…*

This response can be described as…
- expansion
- retreat
- drowning

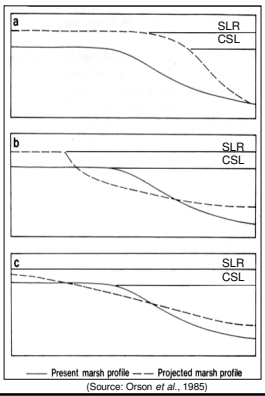
(Source: Orson *et al.*, 1985; Davis, 1987; Reed, 1990, Semenuik, 1994; Cahoon *et al.*, 1996; Day Jr. *et al.*, 1999; Saintilan & Hishomoto, 1999; Simas *et al.*, 2001; Morris *et al.*, 2002)

## Sea Level Rise

***Expansion***
The sedimentation rate equals the rate of sea level rise

***Retreat***
Sedimentation is inadequate for vertical accretion. Landward transgression results

***Drowning***
The sedimentation rate does not supply adequate material to maintain spatial extent




(Source: Orson *et al.*, 1985)

## Groundwater Research

*Groundwater plays a vital role in supplying freshwater flow, nutrients and sediments to wetland habitats…*

• Groundwater contributes up to 20% of freshwater input

• Groundwater exchange is influenced by tidal phase

• Groundwater influences surface elevation through sediment dynamics

• Groundwater plays an important role in nutrient cycling

• Water table responds to rainfall and evapotranspiration

(Source: Mazda *et al.*, 1990; Wolanski, 1992; Hughes, 1998; Gardener *et al.*, 2002; Drexler & De Carlo 2002; Whelan *et al.*, 2005; Mazda & Ikeda, 2006)

## This Study

*The objective of this study is to;*

• Evaluate the influence that tidal inundation plays upon groundwater dynamics within a coastal wetland system

• Examine spatial variance in groundwater parameters and identify contributing factors

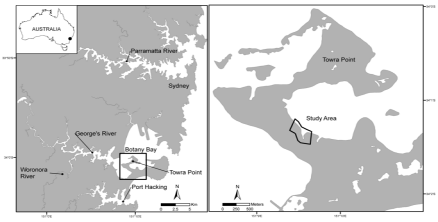
• Identify the role groundwater interactions play in influencing mangrove and saltmarsh species distribution

*In achieving these outcomes the following approach was applied…*
- Field monitoring
- Spatial modelling
- Spatial analysis and statistical testing

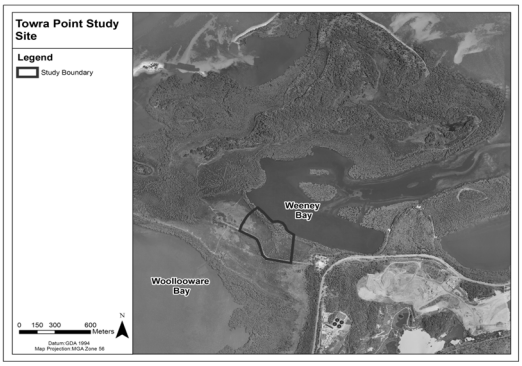
## Towra Point Nature Reserve

• Comprises 50% of the remaining mangrove habitat and 90% of the remaining saltmarsh habitat in the Sydney Region

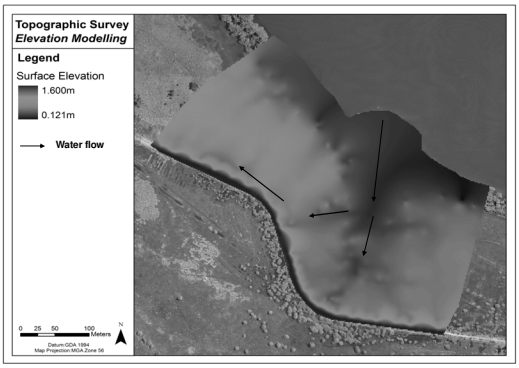
• High conservation values recognised through RAMSAR, CAMBA & JAMBA



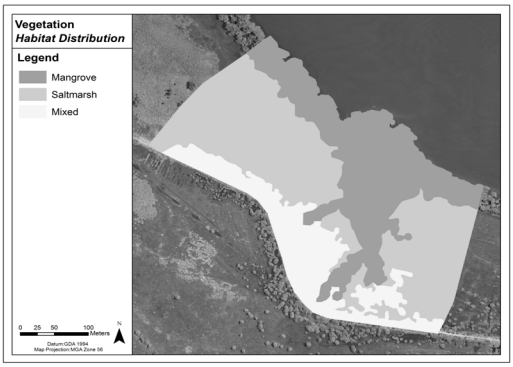
## Study Area




## Topography




## Vegetation Distribution

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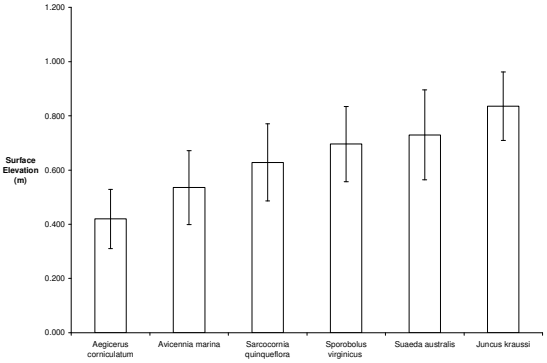
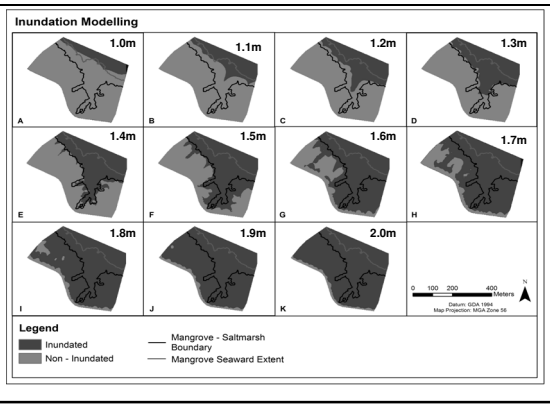
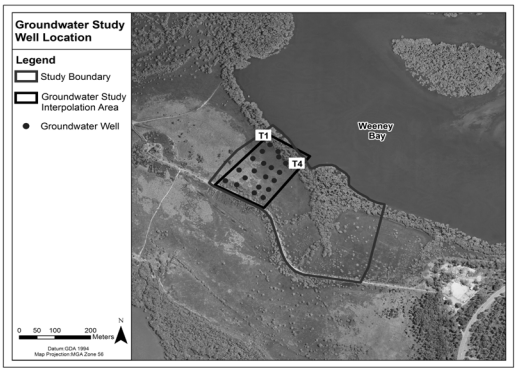



## Tidal Influences




## Groundwater Study Area



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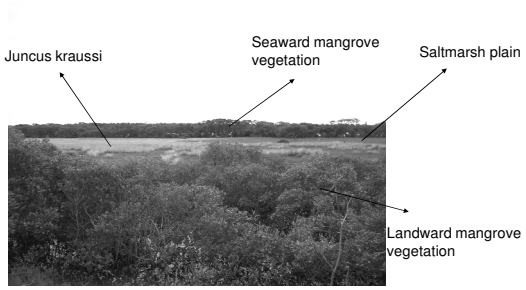
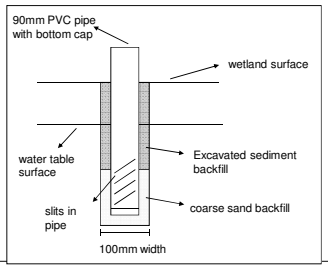



## Groundwater Methodology

- A total of 20 wells were established in the study area
- Water table depth, pH, conductivity & temperature were measured at each well
- Observations were made at high and low tide
- The location of each well was recorded using a GPS




## Groundwater Methodology

- Water table depth was interpolated using the *Spline* function in *ArcGIS*
- Interpolation of pH, temperature and conductivity was undertaken using Inverse Distance Weighting *(IDW)*
- Groundwater values were extracted for mangrove and saltmarsh species
- Correlations between groundwater parameters and surface elevation were examined using the Spearman's Rank procedures
- Kruskal – Wallis tests were performed to test relations between groundwater parameters and mangrove and saltmarsh species distribution
- Mann – Whitney testing enabled examination of the variance in groundwater observations between high and low tide

## Groundwater Correlations

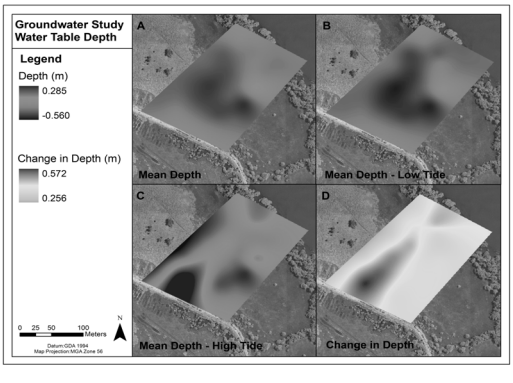
*Positive correlations were found between conductivity & temperature and between water table depth & temperature…*

**conductivity** ↑ **temperature** ↑ | **water table** ↑ **temperature** ↑

*Negative correlations were found between temperature & surface elevation and between water table depth & surface elevation…*

**temperature** ↓ **surface elevation** ↑ | **water table** ↓ **surface elevation** ↑

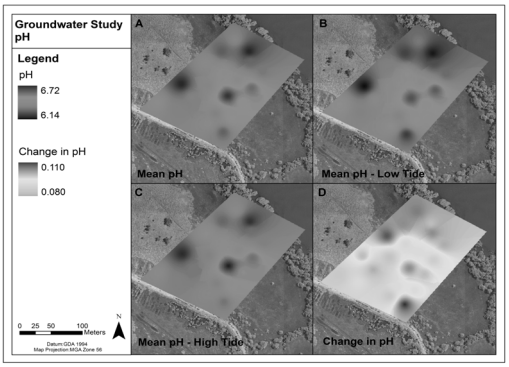
## Results – *Water Table Depth*




## Results – *Water Table Depth*

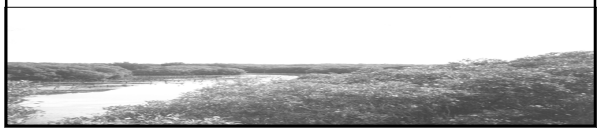
- Statistical analysis revealed a significant difference between the median values for mean water table depth at high and low tide ($W = 318$, $p < 0.05$)
- Water table depth was greatest for *Juncus kraussi* distributions with *Aegicerus corniculatum* and *Avicennia marina* distributions corresponding to shallowest water table depths
- Greatest variation in water table depth was evident for *Sarcocornia quinqueflora* and *Sporobolus virginicus* distributions
- Differences in the mean water table depths between species were found to be statistically significant ($H = 23.99$, $d.f. = 5$, $p < 0.05$)

## Results – *Groundwater pH*

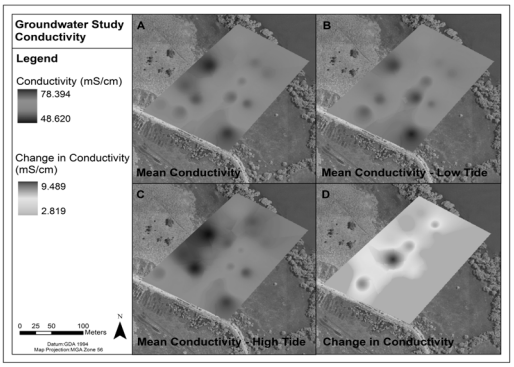



## Results – *Groundwater pH*

- Changes in groundwater pH between low and high tide were found to be minimal and not validated by statistical testing
- *Sarcocornia quinqueflora* and *Sporobolus virginicus* distributions displayed the highest mean pH whilst *Aegicerus corniculatum* recorded the lowest value in mean pH.
- A significant difference in mean groundwater pH between species was Identified ($H = 15.32$, d.f. = 5, $p < 0.05$)

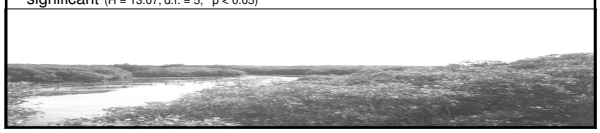


## Results – *Groundwater Conductivity*

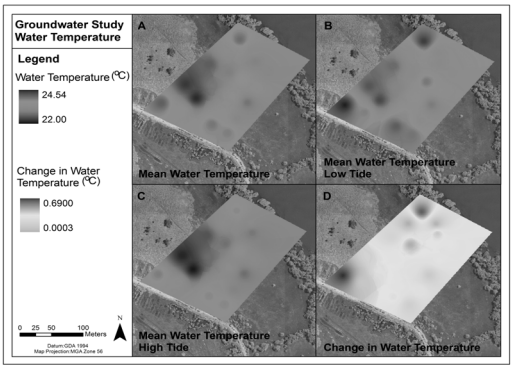



## Results – *Groundwater Conductivity*

- Observed trends in conductivity were apparent at both high and low tide and therefore statistical testing determined tidal influences to be insignificant
- Observed reductions in conductivity toward the western study boundary relate to increases in water table depth
- Higher conductivities were observed toward the seaward edge and along the landward boundary
- *Avicennia marina* distributions displayed the highest mean conductivity while comparatively *Aegicerus corniculatum* recorded the lowest mean value
- Observed differences in conductivity between species were found to be significant ($H = 13.07$, d.f. = 5, $p < 0.05$)

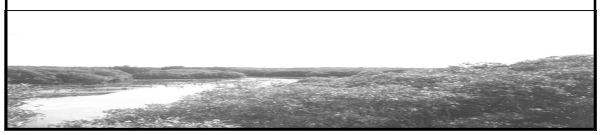


## Results – *Groundwater Temperature*




## Results – *Groundwater Temperature*

- Groundwater temperature was observed to decreases at high tide, however differences were not determined to be statistically significant
- Regions of low groundwater temperature emphasise correlations between temperature & water table depth and groundwater temperature & surface elevation
- *Juncus kraussi* distributions inhabit regions with a lower groundwater temperature, whilst *Avicennia marina* distributions were found in regions where groundwater temperature was higher
- Observed species distributions were found to be significant ($H = 23.15$, d.f. = 5, $p < 0.05$)



## Research Outcomes

• This research highlights the importance of tidal influences upon groundwater dynamics

• Species distributions appear to exhibit tolerance levels to groundwater parameters

• This study reveals a link between groundwater and surface elevation and identifies the importance of this relationship for vegetation distribution

*An understanding of these biophysical interactions/relationships is required to model the impact of predicted sea level rise.*

*More specifically in achieving conservation outcomes, groundwater influences need to be included in predictive species models and as a component of wetland hydrology*