Biological and physical processes affecting salt accumulation dynamics in the Okavango wetland ecosystem, Botswana

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1. Introduction & Background

   a. Summary

      – The Okavango is a major source of freshwater in the Kalahari Desert and is an important migration stop-over for many species (Bauer et al., 2006)
      – The delta is divided into four major physiographic regions, part of which are permanent wetlands while the others are seasonal swamps. The seasonal swamps flood upon receiving water from winter snow melt in October (Milzow et al. 2009).
      – As a freshwater river terminating in an inland delta (seasonal swamps), there are no outflows. Therefore water may only exit the region via evaporation, transpiration or groundwater infiltration (McCarty and Ellery, 1993).
      – It's estimated that 380,000 tonnes of salts, (e.g. carbonate, magnesium, sodium) are carried into the delta each year (Gumbricht, 2004).
      – Salt accumulation should be a problem as the water evaporates, however mechanisms to describe how these salts are removed from the system have been proposed (McCarthy et al., 1993; Bauer-Gottwein et al., 2007; Zimmermann et al., 2006), suggesting the high transpiration rates of woody vegetation leads to salt sequestration underneath tree islands.

   b. Synthesis

      – The fate of solutes underneath tree islands, and the mechanisms by which solute sequestration occurs is fairly well understood, however the role that woody vegetation plays in maintaining low salinity levels within the delta is not clear (Ellery et al. 1993; Bauer et al., 2004).
      – Also of concern is the fact that elephant populations have been growing. There have been more reported sightings of these animals in the Okavango, and an increased frequency of tree denuding and/or destruction (Ben-Shahar, 1993; Ben-Shahar, 1998).
      – Therefore, there are physical factors, including decreased seasonal runoff (Wolski et al., 2006) and increased solute loads (McCarthy et al., 1993) that could potentially affect salt accumulation dynamics in the delta.
      – However there are also biological factors, such as vegetation population dynamics (Neuenschwander 2007) and herbivore grazer dynamics (Ben-Shahar 1998; Mosepele et al., 2009), that might play an important role as well.

   i. Goal of Research/Significance:

      Disturbances to the salt accumulation process could have severe negative consequences for the Okavango, salinizing a source of water that both humans and animals critically depend on. While there is a clear mechanism outlined for how salts are sequestered under tree islands, there has been little work to determine how sustainable this process is given changes in physical and biological processes within the delta. Therefore, the goal of this research is to model the impact of changing three biological/physical parameters within the Okavango Delta to determine what the critical processes are for salt sequestration in this freshwater ecosystem

ii. Question(s):
   1. How will an increase in sediment/solute loads from increased agricultural or urban development affect current salt sequestration processes over the next 100 years?
   2. What is the minimum tree density that needs to be maintained to support current and increased salt sequestration processes over the next 100 years?
   3. How will increased grazing and tree destruction from burgeoning elephant populations affect the salt sequestration processes over the next 100 years?

2. Objectives and Methodology

   a. Objective 1: Data Collection
      i. Solutes: We propose to collect information on annual runoff and solute loads from our contacts at the Okavango Delta Research Center. They have been recording basic water flow and water quality data since the 1950's.
      ii. Trees: We will use satellite imagery to determine where tree islands are within the delta, and tree density. We'll then use existing literature to determine tree transpiration, and life history information
      iii. Elephants: We'll use current population estimates from the ODRC to predict elephant population growth, and estimates from the literature to determine how many trees they destroy over a specified period of time

   b. Objective 2: Model Creation
      We will create a systems model of the Okavango Delta of the solute/vegetation/wildlife dynamics using Microsoft Excel and the Visual Basic Editor (VBE). The model will predict the level of salinity in the seasonal swamps of the delta on an annual basis. The model will be calibrated using existing data to ensure it is functioning properly

   c. Objective 3: Scenario Testing
      Three scenarios will be examined to predict the fate of solutes within the Delta. These three scenarios (below) will focus on changes in solute loading rates, tree populations and elephant populations.
      i. **Business-as-usual-** this will investigate changes in salt sequestration assuming current trends: avg. annual solute load does not change, tree population dynamics are represented by historical average, elephant populations do not increase.
      ii. **Worst case scenario-** this will investigate changes in salt sequestration based on predictions of solute loading, tree and elephant population dynamics under the following assumptions: avg. solute load increases by 2% per year, tree population dynamics are represented by historical average, elephant populations increase at a predicted growth rate of 4% per year.
      iii. **Realistic scenario-** this will investigate changes in salt sequestration based on predictions of solute loading, tree and elephant population dynamics under the following assumptions: annual solute load increases by 0.25% per year, tree population dynamics are represented by historical average, elephant populations decrease at a rate of 0.5% per year until a minimum acceptable population size (to be determined) is reached.

3. Expected Results
    1. **Business-as-usual-** we expect this scenario to show that salinity levels remain approximately the same as they have been in the past.
    2. **Worst case scenario-** we expect that with increased urban and agricultural development in the upper portions of the Okavango catchment, we'll see increased solutes in the form of fertilizers and soil erosion. We'll also anticipate that elephant populations will continue to grow rapidly, and that they will focus their feeding on trees within the delta, destroying more than are re-growing. We expect this will negatively impact salt sequestration under tree islands, and anticipate a steep increase in delta salinity.
    3. **Realistic scenario-** here we expect that planned management or slow growth won't increase solute loads at a rapid rate, and management of elephants will either move, cull or allow increased hunting of these animals such that their populations decrease. We expect to see the increased solute loads being adequately sequestered by tree islands that are flourishing due to a decrease in elephant populations.

4. Conclusions
    a. Results from this modeling effort will help better define the driving processes and important components to maintaining the Okavango Delta as a freshwater resource.
    b. Model results may be used to inform management on development and wildlife management
    c. Future work can include adding additional important model components, and including stakeholders in the scenario development process

5. Budget

Itemized Costs:	Amount Required:	
Salaries:		
PI- Julie Padowski (36 months)	$70,000 x 3 years =	$210,000
PI Benefits [PJ1](36 months)	$17,500 x 3 years =	$52,500
Research Assistant (24 months)	$25,000 x 2 years =	$50,000
RA Benefits (24 months)	$6,250 x 2 years =	$12,500
Tuition, in-state (24 months)	$10,000 x 2 years =	$20,000
Travel:		
Data Collection		
Two flights to Maun, Botswana	$2,000/flight x 2 =	$4,000
Two weeks food and lodging	$1,000/week x 2 =	$2,000
Car rental (2 weeks)	$500/week x 2 =	$1,000
Conference		
Conference Registration	Registration Fee =	$500
Airfare/travel	Domestic flight =	$1,000
Food and lodging	Hotel + per diem =	$1,350
Equipment[PJ2]:		
Computer- 2 desktop computers	$2,000/computer x 2 =	$4,000
Software- Microsoft office	Software expenses =	$500

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