Qualifying Exams Literature Review

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Chapter 1

Introduction

This book is a documentation of the key concepts, findings, and figures of the assigned literature for my qualifying exam. In organizing the literature review in a book, the various concepts are able to be synthesized, interlinked, and mapped to my own research ideas and efforts.

1.1 Research summary

My research interests are broadly focused on parsing apart the relative influence of autochthonous (within the system) vs. allochthonous (from outside of the system) inputs to organic carbon in mangrove sediments. I aim to investigate whether remote sensing and ecoinformatics (standardization and aggregation of disperse field data) can be leveraged to better understand heterogeneity both within- and across-sites.

1.2 Fields of examination

Thus, the topics covered in the exam are namely:

1. Mangrove forest ecology, with an emphasis on regeneration dynamics (Prof. Wayne Sousa)
2. Mangrove soil organic carbon and geomorphology (Prof. Ron Amundson)
3. Remote sensing of wetlands, with a particular focus on mangroves (Prof. Iryna Dronova)
4. Ecoinformatics, tipping points, and decision-making theory (Prof. Carl Boettiger)

1.3 Book format

The book chapters, with subsections for each of the assigned chapters that is identified in a "First author, year of publication" format. Each subsection provides a brief review of the key concepts associated with the article of interest, key findings, and a reprint of any key figures.

1.4 Disclaimer

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Chapter 2

Prospectus

2.1 Project 1

Working title: *"Remote sensing of mangrove geomorphology: A review of existing opportunities and challenges"*

Overview: This chapter will be a review of technological developments in remote sensing, and their potential benefit in the future for remote sensing and better quantification of mangrove geomorphology. The crux of the idea here is that mangrove geomorphology in an applied sense exists largely through nominal definitions, when in actuality there is high heterogeneity within many of the various classes. I will review the literature surrounding mangrove geomorphology from a historical perspective, identify key factors to be quantified or monitored, and look at potential remote sensing applications that exist today, or will be coming online in the next 5 to 10 years.

Target journal: Remote Sensing of Environment

Coauthors:

1. Iryna Dronova (UCB LAEP);
2. Marc Simard (NASA JPL)??
3. MDP

Research questions:

1. What are the existing applications of remote sensing data to hydrology and sedimentary processes in mangrove ecosystems to date?
2. Given new RS data types and their applications in fields outside of mangrove ecology, what opportunities for mapping and better-understanding mangrove geomorphology exist?
3. Given new RS data types and their applications..., what challenges for mapping and better-understanding mangrove geomorphology exist?

Abstract: *For mangrove restoration and conservation projects, it is critical to understand the relationships between mangrove tree species and the geomorphological conditions in which they exist, as well as how they vary over time. While remote sensing of mangrove vegetation is commonplace within the academic literature, fewer studies employ remote sensing to study mangrove geomorphology. The use of remote sensing offers a valuable means to understand mangrove geomorphology at various temporal and spatial scales, as field studies of mangrove hydrology and sedimentary processes are complex and difficult. Given the rapid development of remote sensing technology, a thorough examination of the existing techniques and best practices for better understanding mangrove geomorphology is warranted. Thus, we present here a review of remote sensing of geomorphological processes in mangroves. Our review shows that use of remote sensing to monitor mangrove geomorphology has largely been limited to studies of shoreline erosion and progradation over the*

past few decades. Increasingly available new data sources such as Light Detection and Ranging (LiDAR) and hyperspectral datasets, however, are providing access to novel and informative data layers, such as topography at fine resolutions and total suspended sediment. Leveraging future advances in remote sensing to better monitor mangrove geomorphology will be important for conserving these ecosystems, particularly given increasing global pressures from coastal development and sea level rise.

Relevant literature sections:

1. Zonation & Disturbance - Section 3.1
2. Geomorphology - Section **??**
3. Remote Sensing of Geomorphology - Section **??**

2.2 Project 2

Working title: *"Leveraging ecoinformatics to understand biocomplexity in mangroves"*

(also known as Jacob's attempt to jam as many buzzwords into a title as possible"

Overview: This will be a continuation of the PLoS One work that seeks to couple field data of forest structure and soil characteristics. I currently envisage this as testing for correlations between soil organic carbon stocks and forest biomass, structure, and species composition properties. I am working on building a database for mangroves of the Americas with a URAP student that parallels the one I built for Southeast Asia during my master's work, and am interested in testing the same models on the new dataset. I am also considering getting another URAP student to begin compiling a database for Africa / the middle East, which is the other major region for mangroves. One valuable product would be a comprehensive database of mangrove forest structure and soil characteristics data, with checks on how comparable the different sampling methodologies, datasets, etc. are.

Target journal: TBD

Coauthors: TBD

Research questions:

1. Basal area and latitude were found to be significant predictors of soil organic carbon in mangroves of Southeast Asia when controlling for site-specific effects (e.g., geomorphology). Are the results reproducible in the Americas, a mangrove region that is floristically less diverse than Southeast Asia? Same for Africa / Mid East.

Note: If I am successful in constructing a database of forest structure, species, etc. from the literature, there are many other research questions that can be explored, such as:

1. Examining effects of sea level rise or tidal range on mangrove structure & species assemblages.
2. RS studies such as discrimination of mangrove species or looking at geomorphology (RS data permitting)

This might be difficult, though, as authors may not be forthcoming with data.

2.3 Project 3

Working title: *Variation in forest structure, species and carbon stocks at two equi-latitude deltaic mangroves*

Overview: This chapter will focus on elucidating the differences within two "deltaic" forests in terms of carbon stocks, forest structure, and species diversity. I am sitting on datasets from my time at Yale for two sites on the west and east coasts of peninsular Thailand, that are at relatively equal latitudes. The sites, however, are markedly different in their formation and may have significant differences in terms of topography, morphology, etc. that would make for a nice case study. Preliminary analysis shows that at one site (Krabi) the SOC is exteremely heterogeneous over space, whereas at the other (Pak Panang) SOC is markedly homogeneous. This is likely due to Krabi Potentially collect data on soil texture to couple with dataset and couple with soil organic carbon.

Krabi Estuary, Krabi (Andaman Coast)

- marked by three major fluvial inputs as well as numerous distributaries and intertidal basins

Pak Panang, Nakorn Si Thammarat (Gulf of Thailand)

- deltaic formation from single active tributary
- deposited sediments are reworked by wave action perpendicular to coast to form a chenier upon which a mudflat has formed over time
- likely agricultural sediments given upland land use

Target journal: TBD

Coauthors: TBD

Research questions:

1. How do species composition, forest structure and carbon stocks (AG & BG) vary between equilatitude forests of differing geomorphic position?
2. How much carbon exists within the Krabi River Estuary and Pak Panang mangrove forests (simple C quantification)?

Notes:

- write-up of data from Yale
- look at hydrological models in landscape to support geomorphology characterization (landscape level)

2.4 Project 4

Working title: *Patch dynamics and regeneration in an estuarine mangrove forest due to upland shifts in hydrology*

Overview: This study will examine the influence of a hydroelectric dam built upland of the mangrove forest in Pak Panang, Thailand. There are patches of mangrove die-off, which locals in the forest attribute to the construction of a hydroelectric dam several years prior. I am interested in monitoring the gap dynamics (through RS work), regeneration dynamics within these patches, as well as the emissions of soil C due to the loss of vegetation cover. Most studies have examined direct conversion of mangrove and the resultant soil C losses, but few (if any) have examined shifts in forest structure and extent due to upland shifts in hydrology:

Target journal: TBD

Coauthors: TBD

Research questions: Will suss out later…

Chapter 3

Mangrove forest ecology

This is just some intro stuff here.

3.1 Zonation & disturbance

3.1.1 Preface

Establishment of monospecific stands of mangrove trees in zones parallel to shorelines (zonation) has been among the most well-studied phenomenon in mangroves. Physicochemical gradients exist from the shoreward to landward edges of the intertidal zone, with implications for the recruitment, establishment, and dominance of different mangrove tree species. Several hypotheses attempting to explain zonation in mangroves have existed throughout time:

Zonation as mangrove succession - Davis, 1940:

- From his work in Florida, Davis believed that mangroves promoted shoreline progradation, which was followed by establishment of *Avicennia germinans* species in the most seaward portion of the intertidal zone. Eventually *Rhizophora mangle* with a few *Laguncularia racemosa* individuals would outcompete *A. germinans* as the shore (and thus habitat for *A. germinans*) continued to prograde. Davis believed that the zones of species were a successional process, eventually climaxing in a terrestrial forest dominated by non-mangrove species.

Zonation as response to geomorphic condition - Thom, 1967:

- Thom did his field work in a composite lagoon and riverine system in Tabasco, Mexico, and provided one of the first most comprehensive sets of evidence against Davis's hypothesis of zonation as mangrove succession. In looking at the different habitats in which mangrove tree species existed, Thom concluded that zonation of species was in response to the hydrological and substratum conditions of a site, which were ultimately variables controlled by geomorphic processes. As a result, he concluded that spatial patterns of mangrove species were in response to geomorphic changes in the land rather than mangrove species inducing patterns in geomorphology (and thus species zonation was relatively "stable").

Zonation as adaptation to physico-chemical gradients - Macnae, 1968:

Zonation as result of interspecific competition - Clarke and Hannon, 1971:

Zonation due to tidal sorting of propagules - Rabinowitz, 1978:

- Upon investigating no significant difference in survival and growth rates of *Avicennia, Rhizophora, Laguncularia,* and *Pelliciera* tree individuals planted in monospecific stands in Panama, Rabinowitz concluded that mangrove zonation is not primarily controlled by physiological variables. In response,