BIOC - Submission Confirmation

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Thu 4/9/2015 12:22 AM

Inbox

To: Abdul Malik <jwp495@alumni.ku.dk>;

Dear Mr Abdul Malik,

Thank you for submitting your manuscript, Mangrove Exploitation Effects on Biodiversity and Ecosystem Services, to Biodiversity and Conservation.

During the review process, you can keep track of the status of your manuscript by accessing the following web site:

http://bioc.edmgr.com/

Your username is: abdulmalik1995
Your password is: malik483

Should you require any further assistance please feel free to e-mail the Editorial Office by clicking on "Contact Us" in the menu bar at the top of the screen.

With kind regards,
Springer Journals Editorial Office
Biodiversity and Conservation

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Although for now you don't have to do anything, we would like to let you know about your upcoming options.

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Thu 4/9/2015 1:03 PM

Inbox

To: Abdul Malik <jwp495@alumni.ku.dk>;

Dear Mr Abdul Malik,

Your submission entitled "Mangrove Exploitation Effects on Biodiversity and Ecosystem Services" has been received. Before we can further process it, you are kindly requested to add Continuous line numbers in the manuscript and re-submit the same.

Please log onto Editorial Manager as an author.

The URL is http://bioc.edmgr.com/.

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Please go to the menu item 'Submissions Sent Back to Author', and click on 'Edit Submission'. If no changes are to be made in the metadata, please go immediately to the last submission step 'attach files', and replace the appropriate files. Build the PDF, view your submission, and approve the changes.

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With kind regards,
Renuka Nidhi
Springer Journals Editorial Office
Biodiversity and Conservation

Thank you for your approval

em.bioc.0.425b08.6876497f@editorialmanager.com on behalf of Biodiversity and Conservation (BIOC) <em@editorialmanager.com>

Thu 4/9/2015 1:29 PM

Inbox

To:Abdul Malik <jwp495@alumni.ku.dk>;

Dear Mr Malik,

Thank you for approving the changes that we made to your submission entitled "Mangrove Exploitation Effects on Biodiversity and Ecosystem Services".

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is http://bioc.edmgr.com/.

Thank you for submitting your work to this journal.

Kind regards,

Major Revisions requested BIOC-D-15-00264

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Biodiversity and Conservation (BIOC) <em@editorialmanager.com>

Tue 8/18/2015 6:43 AM

Inbox

To: Abdul Malik <jwp495@alumni.ku.dk>;

Dear Mr Malik,

We have received the reports from our advisors on your manuscript, "Mangrove Exploitation Effects on Biodiversity and Ecosystem Services", which you submitted to Biodiversity and Conservation.

Based on the advice received, I feel that your manuscript could be reconsidered for publication should you be prepared to incorporate major revisions. When preparing your revised manuscript, you are asked to carefully consider the reviewer comments which are attached, and submit a list of responses to the comments. YOU ARE KINDLY REQUESTED TO ALSO CHECK THE WEBSITE FOR POSSIBLE REVIEWER ATTACHMENTS!

In order to submit your revised manuscript, please access the following web site:

http://bioc.edmgr.com/

Your username is: abdulmalik1995
Your password is: malik483

We look forward to receiving your revised manuscript before 13 Oct 2015.

Please make sure to submit your editable source files (i. e. Word, TeX).

Yours sincerely
Renuka Nidhi
JEO Assistant
Biodiversity and Conservation

COMMENTS FOR THE AUTHOR:

BIOC-D-15-00264
Mangrove Exploitation Effects on Biodiversity and Ecosystem Services

Dear Dr. Malik,

we have now received 2 reviews for your manuscript. Excuse the delay in the review process. It was not possible this time to have a speedy review process. You will see that the two reviewers are generally fond of your manuscript, but they make also a range of important comments. In your response letter to us, please detail, how you have addressed the different points.

With best regards
Dirk Schmeller
(Managing Editor)

Reviewer #1: This well-written paper makes a very useful contribution to the literature on mangrove utilisation in Indonesia and the dynamics of mangrove loss and restoration, with particular reference to South Sulawesi.

The descriptive sections of the paper based on empirical work in the field are strong, as far as illustrating the reduction in diversity of mangrove species and changes in forest structure due to utilisation for fuel and other products. A minor quibble: in several sections (e.g. pages 11-15) data is presented to 2 decimal points, implying a need for a level of precision that is not necessary for the point being made.

I have two more significant concerns.

The paper Malik et al (submitted) is cited many times. If this paper is not accepted for publication, or is accepted subject to revisions that affect the sections being cited, then this reference becomes problematic for this paper. In my view it should either be cited as 'unpublished data' or the publication of this paper should be delayed until the other one has been accepted, and then it can be cited as 'in press' with the journal details referenced accordingly.

Finally, with reference to the main conclusion (lines 377-79): "This suggests that the mangroves still perform essential ecosystem functions and thereby degradation, expressed here as lower biodiversity, does not seem to affect ecosystem services."

In my view this statement is not well supported by the empirical data as presented and discussed earlier in the paper. The

residual mangrove communities with their reduced diversity and changed stand structure obviously continue to provide some ecosystem services compared with fully cleared sites. However in order to claim that there has been no effect on ecosystem services, I think you would need to present data comparing a pristine site that has had no disturbance (or at least no clearing for shrimp ponds) with sites that have been disturbed. That would strengthen the paper considerably. For example, would fish catches be even higher in areas with undisturbed mangrove communities?

Lines 371-377 are ambiguous. In particular the sentence: "In fisheries, both in areas characterized by the removal of mangrove and in areas where mangrove is still present but less diverse, the average annual capture of fish, crab, and shrimp per household of fishermen reaches 2,450kg, 338kg, and 213kg, respectively."

This suggests that measurements have been undertaken in fully cleared and partially modified mangrove communities, and that exactly the same production figures (in kg per annum) for fish, crab and shrimp were obtained in each type of forest. That seems hard to believe and at odds with the conclusion further down. Moreover, it is not clear what 'reaches' means: is this the maximum production recorded over a number of years, or an average across a number of households within one year. It would be more clear if it specified a specific time period, the particular areas and communities referred to, and the degree of mangrove modification associated with each set of production data.

While it is beyond the scope of this paper, it would be great to attempt to construct a response curve of the reduction in ecosystem services against levels of mangrove disturbance from pristine to fully cleared. I suspect the relationship is not linear, but it would be extremely useful from a policy and management perspective to understand whether or not there are any apparent thresholds beyond which degradation occurs rapidly, and if so, how they can be described, measured and anticipated.

There is additional documentation related to this decision letter. To access the file(s), please click the link below. You may also login to the system and click the 'View Attachments' link in the Action column.

http://bioc.edmgr.com/l.asp?i=78741&l=TJ71SPUG

REVIEWER #1

Reviewer #1: This well-written paper makes a very useful contribution to the literature on mangrove utilization in Indonesia and the dynamics of mangrove loss and restoration, with particular reference to South Sulawesi.

The descriptive sections of the paper based on empirical work in the field are strong, as far as illustrating the reduction in diversity of mangrove species and changes in forest structure due to utilization for fuel and other products. A minor quibble: in several sections (e.g. **pages 11-15**) data is presented to 2 decimal points, implying a need for a level of precision that is not necessary for the point being made.

Response:
Thanks for the correction. We have revised it.

I have two more significant concerns.
The paper Malik et al (submitted) is cited many times. If this paper is not accepted for publication, or is accepted subject to revisions that affect the sections being cited, then this reference becomes problematic for this paper. In my view it should either be cited as 'unpublished data' or the publication of this paper should be delayed until the other one has been accepted, and then it can be cited as 'in press' with the journal details referenced accordingly.

Response:
Thanks for the suggestion; however, as the paper has been accepted for review we have we decided to change the reference to Malik et al. (in review) throughout the revised manuscript. We have also prompted the journal for a response. Should the manuscript be rejected or undergo substantial changes that affect the citations in the present paper, we will change it to 'unpublished data' at the next revision or the proof stage.

Finally, with reference to the main conclusion (**lines 377-79**): "This suggests that the mangroves still perform essential ecosystem functions and thereby degradation, expressed here as lower biodiversity, does not seem to affect ecosystem services."

In my view this statement is not well supported by the empirical data as presented and discussed earlier in the paper. The residual mangrove communities with their reduced diversity and changed stand structure obviously continue to provide some ecosystem services compared with fully cleared sites. However in order to claim that there has been no effect on ecosystem services, I think you would need to present data comparing a pristine site that has had no disturbance (or at least no clearing for shrimp ponds) with sites that have been disturbed. That would strengthen the paper considerably. For example, would fish catches be even higher in areas with undisturbed mangrove communities?

Response:

Thank you very much for the suggestion. We agree that a comparison with undisturbed mangrove would have been very useful. Unfortunately, we did not observe any undisturbed mangrove in the study area, so it was not possible to do. We have inserted a caveat in the discussion to point this out.

Lines 371-377 are ambiguous. In particular the sentence: "In fisheries, both in areas characterized by the removal of mangrove and in areas where mangrove is still present but less diverse, the average annual capture of fish, crab, and shrimp per household of fishermen reaches 2,450kg, 338kg, and 213kg, respectively."

This suggests that measurements have been undertaken in fully cleared and partially modified mangrove communities, and that exactly the same production figures (in kg per annum) for fish, crab and shrimp were obtained in each type of forest. That seems hard to believe and at odds with the conclusion further down. Moreover, it is not clear what 'reaches' means: is this the maximum production recorded over a number of years, or an average across a number of households within one year. It would be more clear if it specified a specific time period, the particular areas and communities referred to, and the degree of mangrove modification associated with each set of production data.

Response:

Thanks for the comment. The data we have on fish capture is aggregated from capture in different places, including at open sea. Hence, the reviewer is right that we cannot separate different degrees of disturbance of mangrove as a driver of change in fish capture. This is because fish capture is also a function of how much time local people allocate to this activity and this goes down when aquaculture takes over. Hence, we have modified the statement to say that overall fish capture has declined, but that it is difficult to separate the causes of this.

While it is beyond the scope of this paper, it would be great to attempt to construct a response curve of the reduction in ecosystem services against levels of mangrove disturbance from pristine to fully cleared. I suspect the relationship is not linear, but it would be extremely useful from a policy and management perspective to understand whether or not there are any apparent thresholds beyond which degradation occurs rapidly, and if so, how they can be described, measured and anticipated.

Response:

Thanks for the suggestion. This would be very interesting and important, but, as also indicated above, on the basis of our empirical material we cannot produce a robust analysis of such a relationship.

REVIEWER #2

Review: Mangrove exploitation effects on biodiversity and ecosystem services

As a fellow mangrove ecologist I was delighted to have been asked to review this manuscript. The scope and subject content of this research is good and the level of work involved was extensive. However, in this present form I cannot agree to accept for peer review. This work can be published but only if extensive modifications can be met and addressed (see below).

I do feel that there are some gaps and issues with the manuscript structure, which leaves the reader asking more questions. This study is 2-dimensional, yet there are many factors that could explain differences in DBH. I realize that this research is addressing 'exploitation' by removal of forest products, but this alone does not act as a proxy for determining DBH. Some questions, 1) were the sites treated as replicates and how many transects in each forest? 2) What are the site-specific mangrove forest environmental characteristics (were all sites the same?) e.g. salinity, freshwater input, substrata type and height above sea level (immersion time)?

*NB: point being that lower salinity combined with reduced immersion and greater substrata organic content can improve mangrove biomass/productivity/basal area/DBH. Thus, in this present study did any of the forests have low salinity (e.g. high intertidal?), freshwater input, reduced immersion? These variables were not reported and discussed. This could be rectified, but only if the authors have such data. This of course would require a multivariate analysis such as PRIMER.

Response:

Thank you for pointing out this and the suggestions. We designed line transects at each site/forest, built 3 terrace plots at each line transect and conducted 1 replicate. So in each site there are 6 terrace plots.

We do not have data from our own fieldwork for the environmental characteristics. However, based on a previous study by Bahar (2004) the salinity in the islands of Tanakeke and Lantangpeo (site II and I in our study) is in the range of 27 – 31.5 ppt, in the island of Bauluang (site III) it is between of 29 and 30 ppt and in the island of Satangnga (site IV) it is between 30 and 33 ppt. This indicates that salinity in many sites in this area is very similar. Furthermore, Tahir (2000) reported that the characteristic of tides in this area is semi-diurnal (two high waters and two low waters each day). At high tide, the water level reaches 1.5 m (0.3 – 0.4 m above normal sea level) and at low tide it reaches 0.1 – 0.2 m.

This information and the additional references have been inserted in the manuscript under methods and study area

Manuscript structure and ease of reading: the text is verbose and in places has an over use of commas. In areas, sections of text that belong in the Materials and Methods section can be found in the Results section, and some results are found I the Discussion section. A careful and considered COMPLETE re-write is needed. If correctly structured, this will be a nice piece of work. Some details below:

Response:
We have tightened the entire text and rewritten certain parts. See responses to specific comments below

Lines 12 - 15: Re-write, sentence structure. E.g. Mangrove forests are one of the most important coastal ecosystems as they support many local communities. However, over the last two decades mangrove forest harvesting has been extensive. As a consequence, such exploitation has affected mangrove biodiversity and ecosystem services.

Response:
Thanks, we have revised.

Lines 15 – 16: Re-write: We investigate the effect of mangrove harvesting on tree biodiversity in South Sulawesi, Indonesia.

Response:

Thanks, we have revised.

Lines 16 – 19: Re-write: Using (number?) line transects each in ten mangrove forests, mangrove composition, species dominance, density, frequency, stem diameter, and diversity were recorded. Interviews detailing provisioning ecosystem services were also conducted with local forestry and fishery workers to determine the level of exploitation.

Response:

Thanks, we have revised and added the number of line transects at each site.

Line 19: "The study showed that" …The study did not show anything? Re-write: Ten mangrove species were recorded, belonging to six families.

Response:

We have revised.

Line 24: "…dominate in the study area" …this implies just one mangrove site?

Response:

Thanks, we have deleted.

Line 25: Sentence ending in "…have decreased" Not needed.

Response:

Thanks, we have deleted.

Line 25: Mangroves …do you mean, Mangrove forests (?). Here you talk about forests rather than "a site" (see line 24).

Response:

Yes, mangrove forests. We have revised.

Line 26: "Rhizophora sp" Do not italicize 'sp' Also, condense entire sentence. E.g. Of the mangrove forests researched in this study, Rhizophora were found to be the most important and dominant species. Rhizophora was most widely used as it was deemed most suitable for firewood and charcoal.

Response:

Thanks, we have changed the abbreviation 'sp' from italics to regular font throughout the revised manuscript. We also revised the sentence.

The above points are from the abstract. NOTE: I have not addressed the main text with the same details. But, please note, use the same format (noted above) to approach the whole manuscript (it needs attention). Be careful of wordiness, sentence structure and use of commas. Be succinct, punchy and to the point. Be careful with single and/ or plural. Below are some brief points of the main text:

Line 44: Instead of, "The total extent of mangrove forests…" Write, "In 2005, the total area of mangrove forests globally was…" Can you not source a more recent estimate of mangrove area? Your reference is ten years old! Try Spalding's mangrove atlas. Also, Norm Duke – "A World without mangroves" – he talks about mangrove loss, 1 – 2 % per year!

Response:

Thanks, we have revised the sentences. We also thank you for the suggestions to cite the data of global area of mangroves from Spalding et al (2010) and Duke et al (2007). However, we found the data of global area of mangroves and the mangrove loss from Spalding et al. are similar to the 2005 data from FAO (2007) of 150,000 km^2 = 15 million hectares and the loss of mangrove of 35,600 km^2 = 3.6 million hectares. So we believe that Spalding et al. also used FAO (2007) as reference for the global area of mangroves.
In addition, Duke et al. used mainly references from before 2005 (please see the references in their paper) for the mangrove loss 1 - 2% per year.

The loss of global mangrove areas in the past 25 years reported in this manuscript is similar to that reported by Duke et al. and uses the same references. It appears that there is a general need to update global data on mangrove forest extent and losses.

Line 88: Never use "etc"! Suggests that you are too lazy to report. It is up to you to inform, and not leave the reader guessing.

Response:

Thanks, we have deleted and revised the sentence.

Lines 92 – 100: This should be in the introduction.

Responses:

Thanks, we have moved the paragraph to the introduction.

Lines 132 - 135: Did you really measure mangrove composition and structure using a GPS? Whole paragraph needs a re-write.

Response:

Thanks, you are right! GPS was just used to mark the position of the location of measurement. We have deleted it and also revised the paragraph.

Line 136: How many line transects were used per site?

Response:

We used two line transects per site.

Line 158: Data Analysis: You use descriptive stats only, across all sites. Are all the sites environmentally the same? Significantly the same? Basic pairwise tests would be useful, for a start. E.g. species DBH vs. sites. Also, species EVENNESS curves would be useful.

Response:

Please see our first response to reviewer comment above concerning environmental characteristics in this area.

Line 189: Shannon-Wiener is OK. But, I think using actual numbers of Individuals and numbers of different species is far more informative.

Response:

Thanks, you are right that it is far more informative. So we have changed and applied the calculation as suggested.

Line 196: How many communities?

Response:

We have changed the word “communities” to 100 households to specify the focus of the survey.

Line 198: How many surveys?!

Response:

This was an error – there was only one survey, so it has been changed to singular and clarified

Lines 196 – 204: Should be in Materials and Methods, before Data Analysis.

Responses:

Thanks for the suggestion; we have moved this part before Data analysis.

Lines 209 – 214: Whole paragraph: All one sentence! Really???

Response:

We have revised.

Line 224: Do you mean: “Rhizophora mucronata was the most frequent species in all growth stages”.

Response:

Yes, we have revised.

Lines 224 – 228: All one sentence, really?

Response:

Sentence has been rewritten.

Lines 232 – 235: Beginning with, “The Importance Value…” Should be in Materials and Methods.

Response:

Thanks for the suggestion; we have moved this part in Materials and Methods.

Line 243: Remove, “The Shannon-Wiener Diversity (H’) index showed that the”. Begin sentence with, “Diversity values of…”

Response:

Thanks, we have revised the sentence.

Line 251: Wrong, not according to the index intervals. Remove that. You set the arbitrary scale. Begin sentence with, "The diversity values of …"

Response:

Thanks, we have removed the index intervals and revised the sentences.

Line 255: "…of mangrove". Do you mean "mangroves"?

Response:

Yes, and we have revised.

Line 256 – 261: Confused. Needs re-writing.

Response:

Sentence has been rewritten.

Line 266: "mangrove" = "mangroves" ? "area" = "areas" ?

Response:

We have revised.

MANGROVE EXPLOITATION EFFECTS ON BIODIVERSITY AND ECOSYSTEM SERVICES

Abdul Malik[1,2*] Rasmus Fensholt[2] Ole Mertz[2]

[1] Department of Geography, State University of Makassar (UNM), Indonesia. Jl. Malengkeri Raya, Kampus Parangtambung. E-mail: abdulmalik@unm.ac.id.

[2] Department of Geosciences and Natural Resources Management, Section of Geography, ØsterVoldgade 10, 1350 København K. Email: malik@ign.ku.dk; rf@ign.ku.dk and om@ign.ku.dk.

* Corresponding author

Abstract

Mangrove forests ~~is~~ are one of the most important coastal ecosystems as they ~~that provide services and products~~ support~~ing~~ many local ~~and maintaining coastal~~ communities~~livelihoods~~. However, over the last two decades~~,~~ harvesting of mangrove forests ~~harvesting~~ has been extensive~~. As a consequence, such high levels of exploitation have~~ has ~~affected~~ with effects on mangrove biodiversity and~~, consequently, also mangrove~~ ecosystem services. ~~The present study~~We investigate~~s~~ the effect of ~~to what extent~~ mangrove ~~exploitation~~ harvesting on tree ~~has affected~~ biodiversity in ~~a case study area in~~ South Sulawesi, Indonesia. Using two line transects each in ten mangrove forests, mangrove ~~We measured species~~ composition, species dominance, ~~diversity, tree~~ density, frequency, coverage, and stem diameter and diversity were recorded. Interviews detailing ~~with line transects and then associated these metrics with~~ provisioning ecosystem services were also conducted with local ~~such as~~ forestry and ~~fisheries~~fishery workers to determine the level of exploitation. ~~The study showed that ten~~ Ten ~~species of~~ mangrove species were recorded

(*Avicennia alba* Bl., *Bruguiera gymnorrhiza* (L) Lam., *Ceriops tagal* (Pers.) C.B.Rob., *Excoecaria agallocha* L., *Lumnitzera racemosa* Willd., *Nypa fruticans* Wurmb, *Rhizophora apiculata* Bl., *Rhizophora mucronata* Lam., *Rhizophora stylosa* Griff., and *Sonneratia alba* Sm.) belonging to six families (*Avicenniaceae*, *Rhizophoraceae*, *Euphorbiaceae*, *Combretaceae*, *Arecaceae* and *Sonneratiaceae*) ~~dominate in the study area~~. ~~However, the number, diversity, and density of species have decreased. Mangroves~~ Mangrove forests are now dominated by saplings and seedlings, with few trees above 15 cm diameter at breast height. *Rhizophora* sp. ~~is~~ were found to be the most important and dominant ~~mangrove~~ species. *Rhizophora* sp. ~~and it is also~~ was the most widely used as it was deemed the most ~~by communities as it is very~~ suitable for firewood and charcoal ~~production~~. In addition, it is the main species planted in mangrove restoration projects, which have focused on establishing production forest rather than restoring natural species composition and structure. Despite the decrease in biodiversity, the mangroves still provide a wide range of ecosystem services to the communities in the area.

Keywords: Mangrove forests; biodiversity; ecosystem service; Indonesia; Sulawesi.

1. Introduction

~~Mangroves are found in tropical and subtropical coastal regions, approximately between 30º N and 30º S (Giri et al. 2010) and dominated by trees and shrubs adapted to tidal areas (Tomlinson, 1986; Wightman 1989). They are particularly common in sheltered coastlines, lagoons and estuaries that are flooded at high tide and free from inundation at low tide (Nybakken, 1992). The highest mangrove species diversity in the world is found in~~

~~the northern Indian Ocean and the north-western Pacific region, extending from the Red Sea to Indonesia and Japan (Saenger et al., 1983) and of sixty true mangrove species in the world (Saenger et al. 1983), fourty three are found in Indonesia (Kusmana, 1993), which thereby has one of the highest mangrove diversities in the world.~~ Mangrove forests constitute important ecosystems that provide a wide range of services and products for coastal communities, including protection from storms and large waves (Danielsen et al. 2005), preventing coastal erosion and inland intrusion of salt water and pollutants, providing nursery, feeding, and spawning grounds for many marine organisms, and providing products such as fuel wood, charcoal, medicine, and timber (Chang-yi et al. 1997; Wang et al. 2003, Giesen et al. 2007; Ong and Gong, 2013). They are found in tropical and subtropical coastal regions, approximately between 30º N and 30º S (Giri et al. 2010) and are dominated by trees and shrubs adapted to tidal areas (Tomlinson, 1986; Wightman, 1989). They are particularly common in sheltered coastlines, lagoons and estuaries that are flooded at high tide and free from inundation at low tide (Nybakken, 1992). The highest mangrove species diversity in the world is found in the northern Indian Ocean and the north-western Pacific region, extending from the Red Sea to Indonesia and Japan (Saenger et al.~~,~~ 1983) and of 60 true mangrove species in the world (Saenger et al. 1983), 43 are found in Indonesia (Kusmana, 1993), which thereby has one of the highest mangrove diversities in the world.

The~~ir~~ high value of mangrove forests, however, has also generated very high levels of exploitation and deforestation of mangroves is widespread. ~~The total extent of mangrove forests in the world as of~~In 2005, the total area of mangrove forests globally ~~was~~ was about 15.2 million hectares, but this represents a loss of 3.6 million hectares during the previous

25 years (FAO, 2007). Indonesia, the country with the largest mangrove area in the world, lost 1.2 million hectares in the same period, or about one quarter of the mangrove area, with about 3.2 million hectares of mangrove forest remaining (Bakosurtanal, 2009).

Besides permanent deforestation, the exploitation often changes the biodiversity of remaining mangrove forests, reducing the number and abundance of species, and changing the species composition and structure. Walters (2005) reported that wood cutting in mangroves in the Philippines caused forest structure change and altered species composition, especially at the expense of less resilient species, and mangrove forest degradation in terms of reduced biodiversity has also been reported in Cameroon (Din et al. 2008) and Bangladesh (Iftekhar and Takama, 2008). Several studies in Indonesia also document reduced diversity in mangrove forests. ~~Onrizal and Kusmana (2008) found that~~ C~~c~~ollection of firewood and charcoal production on the east coast of North Sumat~~e~~ra led to decreasing mangrove areas and forests were dominated by seedlings and saplings ~~and~~ with few mature trees (Onrizal and Kusmana 2008). Similarly, in the Segara Anakan Lagoon, Central Java, wood cutting and high sedimentation rates from rivers inhibited the growth of some mangrove species (*Sonneratia* sp., *Rhizophora* sp. and *Bruguiera* sp.) compared to the 1980s (Hinrichs et al. 2008). In the same area, ~~Suryono (2006) reported that during the period 1930 to 1996~~ the mangrove area had been reduced by about 23,000 hectares between 1930 ~~to~~and 1996 and changes in species composition, ~~and the~~ structure of population and distribution pattern were observed (Suryono, 2006). Overall, there has been a decrease in the number of mangrove species in all the main islands of Indonesia except the Maluku Islands (where no expansion in ~~shrimp farming~~ aquaculture ~~pond~~ has been observed~~,~~ ~~(Malik et al. submitted~~unpublished data~~)~~), as seen in Table 1.

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<Table 1. Insert>

There are indications that reduced biodiversity of ecosystems may negatively affect a range of provisioning, regulating, cultural and supporting ecosystem services (Harrison et al. 2014; Millennium Ecosystem Assessment, 2005). Costanza et al. (2006) went so far as to propose that a change of 1% of the species composition will result in a change of 0.5% of the ecosystem services value, and Benayas et al. (2009) suggested that increasing biodiversity by 44% will increase ecosystem services by 25%. However, as Harrison et al. (2014) point out, there is a need for a more solid knowledge base on the linkages between biodiversity and ecosystem services, including analysis of more case studies where longitudinal changes can be observed. It is not in all cases evident whether high biodiversity is required for sustaining a high level of ecosystem services or whether most of the ecosystem services can be provided by low diversity (Cameron, 2002; Mertz et al. 2007).

Hence, in this paper we investigate the effects of mangrove exploitation on biodiversity and relate this to changes in ecosystem services in one of the hotspots of mangrove exploitation in Indonesia, South Sulawesi, an area that has not been subject to many studies previously. In particular, we are interested in understanding whether changes in biodiversity have affected the supply of provisioning ecosystem services, such as firewood, timber, charcoal, Nypa palm leaves, fish, crabs and shrimps~~fisheries, etc~~. We use transects to assess current tree diversity and use historical data and interviews to assess the impact of changes in diversity on ecosystem services.

2. ~~Mangrove Distribution and Selection of~~ Study Area

~~Mangroves are found in tropical and subtropical coastal regions, approximately between 30º N and 30º S (Alongi, 2002; Giri et al. 2010) and dominated by trees and shrubs adapted to tidal areas (Tomlinson, 1986; Wightman 1989). They are particularly common in sheltered coastlines, lagoons and estuaries that are flooded at high tide and free from inundation at low tide (Nybakken, 1992). The highest mangrove species diversity in the world is found in the northern Indian Ocean and the north-western Pacific region, extending from the Red Sea to Indonesia and Japan (Saenger et al., 1983) and of 60 true mangrove species in the world (Saenger et al. 1983), 43 are found in Indonesia (Kusmana, 1993), which thereby has one of the highest mangrove diversities in the world.~~

The chosen study area in Indonesia – Takalar District, South Sulawesi – is therefore considered an appropriate case as it represents one of the most mangrove rich regions where this forest type is under strong pressure from exploitation. The area is located between latitude 5°12' - 5°38' and longitude 119°10'- 119°39' (Figure 1), about 45 km from the capital of South Sulawesi, Makassar City. The district covers 566,5~~1~~ km^2 and is divided into nine sub-districts (Galesong, South Galesong, North Galesong, Mangarabombang, Mappakasunggu, Pattalassang, South Polo~~ng~~mbangkeng, North ~~Polongbangkeng~~ Polombangkeng and Sanrobone). Mappakasunggu consists of a mainland part and some small islands (Tanakeke, Lantang~~ P~~peo, Bauluang, Satangnga and Dayang dayangan~~ Dayang~~). The population is 272,316 persons with a population density of 481 persons per km^2 (BPS-Kab. Takalar~~Statistics of Takalar District~~, 2012). The district has a coastline of 74 km (Ukkas, 2001) characterized by mangrove, coral reefs, sea grass, sandy

beaches, rocky beaches, estuaries, ponds, rice fields, and both residential areas and areas of tourism interest (BPS-Kab. Takalar, 2012).

In this study, ten sampling sites were selected covering mangrove in mainland (villages of Laikang, Limbungan, Banyuanyara, Saro', Tamasaju, and Aeng Batu ~~Batu~~batu) and small islands (Lantangpeo ~~Peo~~, Tanekeke, Bauluang and Satangnga). The sampling sites were chosen due to increasing collection of wood by local communities and because mangrove restoration projects involving local communities, government and NGOs have been conducted. Mangroves on the mainland are most commonly distributed along the coasts, except for riverine mangrove forest in Limbungan village ~~(riverine)~~. The exploitation of mangroves is mainly for firewood, but in some sites (Tanakeke Island and Banyuanyara villages), ~~shrimp~~ aquaculture ~~pond~~ expansion is the dominant activity and in Limbungan village, collection of Nypa palm for handicrafts is more important. In the small islands, mostly thin strips of mangrove are found along the coast for wave protection whereas ~~as~~ the inner parts of the mangrove areas generally have been degraded, ~~and lost due to development of~~ converted to ~~shrimp~~ aquaculture ponds or felled for fuelwood, charcoal production and trade. ~~The thin strips of mangrove are kept for wave protection, as on Tanakeke Island (Malik et al. submitted~~unpublished data~~).~~ The environmental characteristics of the mangroves in the study sites are quite similar. Bahar (2004) showed similar salinity in the sites of the present study (Tanakeke and Lantangpeo 27-31.5 ppt, Bauluang 29-30 ppt and Satangnga 30-33 ppt) and Tahir (2000) reported that the semi-diurnal tides reach 1.5 m (0.3 – 0.4 m above normal sea level) at high tide and 0.1 – 0.2 m at low tide in all islands.

Figure 1 <insert>

3. Materials and Methods

~~To measure the m~~~~B~~~~t~~The biodiversity of mangrove, forests including ~~composition~~ species composition and structure, weas~~re~~ measured ~~, we used~~ using ~~the Global Positioning System (GPS),~~ a compass, clinometers, a large knife, measuring tape, a tally counter, plastic rope, a tally sheet, a camera, and a reference book for identifying mangrove species.

The data were collected in August 2012 using the line transect method (English et al. 1997; Frontier Madagascar, 2005; Simon, 2007). This method is standard for estimating species composition and dominance, diversity, tree density, frequency, coverage, and stem diameter in sample plots located on a line drawn through the mangrove forest.

We ~~designed~~implemented two line transects per site, ~~with The~~ the length ~~of line transects depended~~depending on the thickness of the mangrove forest from the seaward edge to the landward margin ~~at each site~~. Each starting and end point of the transects and zone boundaries was marked by GPS (Global Positioning System) (English et al. 1997; Frontier Madagascar, 2005; Simon, 2007). We used 90 m line transects for sites III (Bauluang Island), V (Laikang Village), VI (Limbungan Village), VII (Banyuanyara Village), VIII (Saro' Village), IX (Tamasaju Village), and X (Aeng Batub ~~B~~atu Village), ~~whereas~~ and 50 m line transects ~~were used~~ for sites I (Lantang ~~Peo~~peo Island), II (Tanakeke Island), and IV (Satangnga Island). On each line transect, we established three terraced plots using measuring tape and plastic ropes. On the 90 m line transect, the plots were 30 m apart and on the 50 m line transect, they were 10 m apart (figure 2). The size of each plot was 10m x 10m for tree level, 5m x 5m for sapling level, and 2m x 2m for seedling level.

Furthermore, we recorded the species name and individual number of mangrove trees, saplings, and seedlings found in each plot and measured the ~~Diameter~~ diameter at ~~Breast~~ breast ~~Height~~ height (DBH) of the stems ~~at a height of 1.3 m from the ground~~ (English et al. 1997; Frontier Madagascar, 2005; Simon, 2007).

Figure 2 <insert>

~~**Data on Provisioning of Mangrove Ecosystem Services**~~

Data on provisioning ~~of~~ ecosystem services including forestry products (firewood, charcoal, and Nypa palm craft) and fisheries products (fish, crab and shrimp capture, and aquaculture) were obtained from households who live around mangrove areas based on ~~.~~ ~~These data were produced from~~ a household survey~~s~~ undertaken in ten areas of Takalar district in South Sulawesi. Questionnaires were administered to 100 households, who were selected by a Purposive Sampling method. Information was collected on the respondents' understanding of mangrove functions and benefits, details of their use of mangrove forests, such as forest type and age as well as frequency of use, the amount earned per utilization and the operation costs involved. Further details and the reporting of these results are found in Malik et al. (in review) and in Malik et al. (2015).

Data Analysis

The species density, relative density, species frequency, relative frequency, and species coverage and relative coverage were calculated by the formulas 1 to 6: (Curtis and McIntosh, 1950)

$$Di = \frac{ni}{A} \text{..... (1), and} \quad RDi = \frac{ni}{\sum n} \times 100\ \% \text{ ..... (2)}$$

Where: Di = density of species i (individual/ha)

RDi = relative density of species i (%)

ni = number of counts per species i

Σn = total number of counts for all species

A = total area of the sample observed (ha)

$$Fi = \frac{Pi}{\sum p} \text{..... (3), and} \quad RFi = \frac{Fi}{\sum F} \times 100\ \% \text{ ..... (4)}$$

Where: Fi = frequency of species i

RFi = relative frequency of species i (%)

pi = number of plots where species i occurs

ΣF = total number of occurences for all species

Σp = total number of plots observed

$$Ci = \frac{BA}{A} \text{..... (5), and } RCi = \frac{Ci}{\sum C} \times 100\ \% \text{ ..... (6)}$$

Where: Ci = areal coverage for species i

BA = $\pi DBH^2 / 4$, where BA = Basal Area (cm) and

DBH= Diameter at Breast Height (cm)

A = total area of plot (m^2)

ΣC = total area coverage for all species

RCi = relative coverage of species i (%)

The Importance Value Index (IVI) was calculated by the sum of Relative Density, Relative Frequency, and Relative Coverage to express the dominance level of individual mangrove species (formula 7): (Curtis, 1959)

$$IVI = RD + RF + RC \quad \text{..... (7);}$$ ~~where~~ the range of IVI = 0 - 300

The diversity index (~~H'~~D) of mangrove species was calculated by ~~the Shannon-Wiener index (1963)~~ the actual number of different species and total number of individuals (formula 8):

$$D = \sum \frac{ni}{N}$$

~~$H' = \sum_{i=1}^{n} \left[\frac{ni}{N}\right] \ln \frac{ni}{N}$~~ ..... (8); the range of D = 0 – 1 (0 = no diversity; 1 = high diversity)

~~Where: H' = Shannon-Wiener index~~
~~(Ni) = the sum of the importance value of each mangrove species~~
~~N = importance value of all species~~

Where: ni = number of different species in the area

N = number of individuals in the area

~~Data on Provisioning of Mangrove Ecosystem Services~~

~~Data on provisioning of ecosystem services were obtained from 100 households on forestry products (firewood, charcoal, and Nypa palm craft) and fisheries (fish, crab and shrimp capture, and aquaculture). Data were produced from household surveys undertaken in ten areas of Takalar district in South Sulawesi. Questionnaires were administered to 100 respondents, who were selected by a Purposive Sampling method. Information was collected on the respondents' understanding of mangrove functions and benefits, details of~~

~~their use of mangrove forests, such as forest type and age as well as frequency of use, the amount earned per utilization and the operation costs involved. A detailed description can be found in Malik et al. Submitted.~~

4. Results

4.1. Composition and Dominance

A total of 1,850 mangrove trees were recorded, comprising mature trees (27~~.46~~%), saplings (40~~39.89~~%) and seedlings (33~~2.65~~%) (Table 2). Ten mangrove species were recorded (*Avicennia alba* Bl., *Bruguiera gymnorrhiza* (L) Lam., *Ceriops tagal* (Pers.) C.B.Rob., *Excoecaria agallocha* L., *Lumnitzera racemosa* Willd., *Nypa fruticans* Wurmb, *Rhizophora apiculata* Bl., *Rhizophora mucronata* Lam., *Rhizophora stylosa* Griff. and *Sonneratia alba* Sm.), ~~and~~ belonging to six families (*Avicenniaceae, Rhizophoraceae, Euphorbiaceae, Combretaceae, Arecaceae, and Sonneratiaceae*). ~~and 10 species (*Avicennia alba, Bruguiera gymnorrhiza, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa, Nypa fruticans, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, and Sonneratia alba).~~

<Table 2. Insert>

<Table 3. Insert>

At each sampling site, two to six species were recorded, with sites VII, VIII, and X having the highest number of species. *Rhizophora mucronata* Lam. grows by the seaside and was found at all sites, whereas *Nypa fruticans* Wurmb~~*palm*~~ was only found in the

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riverine site VI as the palm is only suited for this environment. At site V, only two mangrove species were found as this area has been subjected to mangrove restoration (Table 3).

~~Trees in~~ The density of *Rhizophora mucronata* Lam. made this species dominant ~~at~~in all ~~recorded~~ growth stages ~~are dominance. ted by *Rhizophora mucronata* (tree = 0.076 ind/ha; RD = 4445.88%; sapling = 0.091 ind./ha; RD = 3637.9%, and seedling = 0.06 ind./ha; RD = 29.9730%)~~, followed by *Rhizophora stylosa* Griff. for mature trees ~~(0.163 ind./ha; RD = 9.610%)~~, *Rhizophora apiculata* Griff. for saplings ~~(0.048 ind./ha; RD = 19.6520%)~~, and *Bruguiera gymnorrhiza* (L) Lam. for seedlings ~~(0.026 ind./ha; RD = 12.9113%)~~.

The frequency ~~is~~ was also dominated by *Rhizophora mucronata* Lam. at all levels of regeneration ~~(0.8; RF = 29.230%)~~, followed by *Rhizophora stylosa* Griff., *Avicennia alba* Bl., and *Sonneratia alba* Sm. ~~(0.367; RF = 13.41%)~~. Finally, the coverage is also dominated by *Rhizophora mucronata* Lam. ~~(1.32; RC = 21.13%)~~, followed by *Sonneratia alba* Sm. ~~(1.14; RC = 18.2%).~~

~~The Importance Value Index (IVI) is calculated from relative density (equation 2), relative frequency (equation 4), and relative coverage (equation 6) to express the dominance level of individual mangrove species.~~ The IVI showed that *Rhizophora mucronata* Lam. was the dominating species at all levels of regeneration ~~(tree = 95.3%; sapling = 66.3%; and seedling = 59 .23%)~~, followed by *Sonneratia alba* Sm. ~~(tree = 38 .33%),~~ whereas for saplings and seedlings, *Rhizophora apiculata* Bl. ~~(33 .06%)~~ and *Avicennia alba* Bl. ~~(25.506%)~~ dominated, respectively (Table 4).

<Table 4. Insert>

4.2. Mangrove Species Diversity

~~The Shannon-Wiener Diversity (H') index showed that the d~~Diversity values of mangrove species at tree level were between ~~1.05~~0.04 and ~~1.72~~0.22, whereas for saplings they were between ~~0.67~~0.02 and ~~1.77~~0.17 and for seedlings, between ~~0.62~~0.05 and ~~1.74~~0.11. The highest diversity for trees ~~is~~ was found at site ~~X~~VIII, whereas for saplings it ~~is~~ was found at site ~~VII~~ VI and for seedlings~~,~~ at sites ~~VII~~ VI ~~and X~~ (Table 5). However, the diversity values of mangrove at all ~~of~~ growth stages and sites ~~indicate has~~were very low.

<Table 5. Insert>

~~According to the index intervals of the Shannon-Wiener index, the diversity values of mangrove trees , saplings, and seedlings at sites II, VII, VIII, and X were medium (1.5 - 3.0), whereas at a majority of sites (I, III, IV, V, VI, and IX) they were low (<1.5).~~

4.3. Frequency Distribution of Diameter Size Classes for All Mangrove Species

The ~~Diameter at Breast Height (~~DBH~~)~~ of mangrove~~s~~ trees ~~is~~ was between 6~~.37 cm~~ and 2~~43.57~~ cm. The ~~frequency distribution of diameter size classes of all mangrove species showed that the~~ diameter size classes of 10 – 15 cm dominated, followed by 15 – 20 cm. *Rhizophora mucronata* Lam. had the highest frequency in~~, with~~ the diameter classes ~~of~~ 10 – 15 ~~cm~~, 15 – 20 ~~cm~~, and <10 cm, ~~has the highest frequency (F = 10; 8; and 5),~~ whereas *Rhizophora stylosa* Griff. ~~has~~ had the highest frequency in diameter classes of more than 20 cm. All mangrove species (10 in total) ~~are~~ were ~~found~~ represented in the 10 – 15 cm

diameter size class and eight species ~~are~~ were found in the 15 – 20 cm diameter size class (Figure 3).

<Figure 3. Insert>

5. Discussion

The species composition of mangroves in the study area consisted of ~~10~~ ten species, all of which are well known in the region of Indonesia (FAO, 2007) and belong to what is taxonomically known as 'true mangrove species' (Tomlinson, 1986).

Compared with the total ~~number of~~of 27 mangrove species in Sulawesi Island ~~(27 species~~ (Kusmana, 1993)~~)~~, 43 in Indonesia ~~(a total of 43 species~~ (Kusmana, 1993)~~)~~, and 60 species worldwide ~~(60 species~~ (Saenger et al. 1983)~~)~~, this indicates that 37%, 23%~~,~~ ~~a~~and 17%, respectively, of the total true mangrove species known are present in this case area~~, respectively~~.

In a similar area in South Sulawesi, Nurkin (1994) recorded ~~18 eighteen~~18 species in the early 1990s indicating that there has been a reduction in the number of species over the past two decades. Four of the ten species found in the present study area (*Avicennia alba* Bl., *Excoecaria agallocha* L., *Lumnitzera racemosa* Willd., and *Rhizophora stylosa* Griff.) were not recorded ~~in~~ by Nurkin (1994). By contrast, ~~12 twelve~~12 species (*Acanthus ilicifolius* L., *Acrostichum aureum* L., *Aegiceras corniculatum* (L.) Blanco, *Avicennia marina* (Forssk.) Vierh., *Bruguiera parviflora* (Roxb.) Wight & Arn. ex Griff., *Heritiera littoralis* Aiton, *Lumnitzera littorea* Willd., *Scyphiphora hydrophyllacea* Gaertn.,

Sonneratia acida L.f., *Sonneratia ovata* Backer, *Xylocarpus granatum* K.D.Koenig, and *Xylocarpus moluccensis* (Lam.) M.Roem.) were not found in the present study.

Furthermore, the number of true mangrove species was also lower than what was found in a number of other sites in Southeast Asia. These include ~~in~~ Balok River Pahang of Malaysia (12 species, ~~) (~~Rozainah and Mohamad, 2006), ~~on~~ the east coast of North Sumat~~e~~ra (17 species, ~~) (~~Onrizal and Kusmana, 2008), Aurora, Philippines (18 species, ~~)~~ ~~(~~Rotaquio et al. 2007), Sundarbans Delta, Eastern India (24 species, ~~) (~~Barik and Chowdhury, 2014), and Segara Anakan Lagoon ~~(SAL)~~ in Central Java of Indonesia (26 species, ~~) (~~Hinrichs et al. 2008).

In addition to the generally low number of species in the study area, there ~~is~~ was also a clear dominance of one or two species, especially *Rhizophora* sp., which could indicate instability of the ecosystem (Krebs, 1989). Stable ecosystems occur if the species population density tends towards equilibrium after a disturbance and no one species becomes dominant. The relative density, frequency, and coverage of mangroves were all below ~~about~~ 50% (Table 4), indicating that there are large areas of open forest and that the rate of biodiversity of species is ~~dwindling~~declining. Due to ~~the~~ regeneration, ~~of~~ mangrove, composition in ~~this~~ our study area was dominated by saplings and seedlings, followed by mature trees with DBH dominance between 10 ~~cm~~ and 15 cm and it was ~~. It was evident that mangrove forest in this area was in a growth phase after disturbance and it was~~ hard to find mature mangrove. This pattern is similar to what occurred on the east coast of North Sumat~~e~~ra (Onrizal and Kusmana, 2008).

The disturbance has primarily been caused by the expansion of ~~shrimp~~ aquaculture ponds~~, which results in the clear cutting of~~whereby patches of mangrove forest are clear-

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cut ~~mangroves,~~ and secondly~~, from~~ by degradation of forests through timber ~~wood cutting for~~harvesting and collection of firewood for charcoal production~~, timber, and charcoal production~~, see ~~see f~~Figures 4A and 4B (Malik et al. ~~submitted~~unpublished ~~data~~in review). The conversion of mangrove forest to ~~shrimp~~ aquaculture ~~ponds~~ has increased in past decades in several sites within the study area and in 2012 reached 77~~.45~~% of the total mangrove area, with an annual expansion of ~~4.985~~% from 1979 to 1996. The expansion of ~~shrimp~~ aquaculture ~~ponds~~ has mainly taken place in Tanakeke Island and Banyuanyara village, whereas wood cutting activities have increased in all areas and primarily in Lantangpeo and Satangnga Islands (Figure 4A) (Malik et al. ~~submitted~~unpublished ~~data~~in review). The local population prefers to cut *Rhizophora* sp. trees when they have a length of at least 4 m and a diameter of 4 - 8 cm (Figure 4B) (Malik et al. ~~submitted~~unpublished ~~data~~in review). They favor this species for firewood as it is more durable when burned at a high temperature, produces low emissions of smoke, has a fragrant aroma, and is more profitable when marketed than other types of firewood (Nurkin, 1994; Weinstock, 1994; Malik et al. ~~submitted~~unpublished ~~data~~in review). Thus, the proportion of individual *Rhizophora* sp. trees with a diameter of (4 - 8 cm) is lower (Figure 3), whereas the other sizes prove that the trees regenerate successfully. The fact that people are very selective with regard to which species they use and the desirable sizes of the trees is similar to what was found by Walters (2005) in the Philippines ~~mangrove~~, where preferences for *Rhizophora* sp. ~~and~~ including *Rhizophora mucronata* Lam. were also recorded.

<Figure 4A and 4B. Insert>

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In general, tThe dominance of *Rhizophora* sp. is similar to other areas in Southeast Asia, such as Sundarbands Delta, Balok River Pahang, Matang in Malaysia, and Segara Anakan Lagoon, in Central Java, Indonesia. Out of 24 true mangrove species that were measured in the Indian Sundarban Delta, the highest number of species belonging to the *Rhizophoraceae* family is found (nine species, including *Rhizophora mucronata* Lam. and *Rhizophora apiculata* Bl.) (Barik and Chowdhury, 2014). Giri et al. 2014 reported that the inner part of the mangrove forest in Indian Sundarban is ~~mainly~~ dominated by *Rhizophora* sp., *Excoecaria* sp., and *Bruguiera* sp. The communities who are living around the delta have been using these species for tannin, fuelwood, and timber, and their leaves as medicines such as *Rhizophora mucronata* Lam. for angina, *Bruguiera gymnorrhiza* (L) Lam. for diarrhea and blood pressure, and *Excoecaria agallocha* L. for leprosy (Frost, 2010). In Balok River Pahang, *Rhizophora apiculata* Bl. was the most common, with the highest density and IVI, followed by *Rhizophora mucronata* Lam. (Rozainah and Mohamad, 2006). Similarly, the 40,000 hectares of mangrove forest in Matang, Malaysia are dominated by *Rhizophora apiculata* Bl. (Ong, 1982), whereas in Segara Anakan Lagoon, dominance is shared between *Rhizophora apiculata* Bl., *Aegiceras corniculatum* (L.) Blanco, and *Nypa Fruticans* Wurmb (Hinrichs et al. 2008). In these three areas, *Rhizophora* sp. is mainly used for fuelwood and charcoal production by communities for domestic and commercial purposes. In addition, they also use tree bark from *Rhizophora* sp. as medicine to cure diarrhea and stop hemorrhages, whereas the leaves, buds, fruits, and seedlings (propagules) of some *Rhizophora* sp. have been used for food consumption (Rozainah and Mohamad, 2006; Jusoff and Taha, 2008; Sastranegara et al. 2007). Contrary to this, the east coast of North Sumatera and Aurora, Philippines, are dominated by

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Avicennia marina (Forssk.) Vierh. (Onrizal and Kusmana ~~C.~~, 2008; Rotaquio et al. 2007), but *Rhizphora* sp. is still one of the most utilized species for firewood and charcoal production (Onrizal and Kusmana, 2008; Primavera, 2000).

The many uses of *Rhizophora* sp. also make it the favored species ~~to replant to restore the~~for restoration of mangrove forests indicating~~. This indicates~~ that while mangrove restoration ~~activities are~~is mainly argued from a conservation point of view, the choice of species has clear economic aims; essentially, a production forest is created, as has also been reported by Weinstock (1994). Thus, most mangrove restoration projects implemented by governments and NGOs that also involved local communities in Southeast Asian countries have mainly focused on planting one or two species and very often using monocultures of *Rhizophora* sp. (Gan, 1995; Ellison, 2000; Primavera and Esteban, 2008). It is therefore clear that with its fast regeneration and by being favored for restoration, this species will continue to dominate in the future ~~because besides being planted it easily regenerates, as indicated by the high number of saplings and seedlings~~.

Despite mangroves having been deforested and degraded in South Sulawesi ~~this area, subsequently causing~~with a decline in biodiversity as the result, mangrove forests still provide ecosystem services that are critical to local ~~communities'~~ livelihoods. Communities still benefit from mangroves in the form of forestry products (firewood, charcoal production, and Nypa palm crafting) and fisheries products (fish, shrimp, crab, and aquaculture). For instance, in Lantangpeo and Satangnga Island areas, where less diverse mangroves exist mainly due to wood cutting practices, communities still benefit from household consumption and ~~trade~~ sale of firewood and charcoal. On a monthly basis, a household can collect an average of five bundles (1 bundle = 100 stems and 1 stem = 1

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meter) of firewood (primarily from *Rhizophora* sp.), providing an average income of ~~IDR 400,000 (~~42 USD 42~~ 42)~~, whereas a charcoal producer can produce 500 kg per month, corresponding to an average income of about ~~IDR 3000,000 (~~316 USD 300~~ 316)~~. In Limbungan Village, where ~~most common communities collect~~ Nypa palm leaves are collected for ~~hand~~ crafting ~~(mainly for~~of hats, ~~but also for~~ roofs, walls, floor mats, and baskets~~)~~, they can gather leaves (up to 100 bundles per operation; 1 - 2 times per month), yielding an income of up to USD ~~to IDR 3,000,000 (~~316 00 ~~USD 316)~~ per month (Malik et al. ~~submitted~~unpublished ~~data~~in review). In Tanakeke Island and Banyuanyara Village, where mangroves have been removed mainly due to conversion to ~~shrimp~~ aquaculture ~~ponds~~, ~~the thin~~a thin belt of ~~-~~mangrove trees are still left on the outside of the ponds and borders of the sea to protect the ponds from abrasion (Malik et al. ~~submitted~~unpublished ~~data~~in review). ~~In fisheries, both in areas characterized by the removal of mangrove mainly due to expansion of aquaculture ponds such as (Tanakeke island and Banyuanyara village and), the average yield of fish capture per household reaches 2,771 kg/yr, whereas iin areas where mangroves also has been disturbed but at least no clearing for aquaculture pond (Islands of Satangnga and Bauluang), , the average yield of fish capture per household reaches 1,877 kg/yr. and in areas where mangrove is still present but less diverse, the average annual capture of f~~Overall, fish, crab, and shrimp capture per household of fishermen ~~reaches~~ were 2,450 kg/yr, 338 kg/yr, and 213 kg/yr, respectively, and the studied households claimed that this is a decrease compared to the past (Malik et al, in review). However, this decrease may because households focus their activities on ~~In addition,~~ shrimp production from aquaculture ponds, which ha~~ve~~s increased both ~~, which can increase~~ farmers' income~~, export value,~~ and state revenue and provided new opportunities

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for alternative employment for communities (Malik et al. ~~submitted~~in review). This suggests that the mangroves still perform essential ecosystem functions and thereby that degradation, expressed here as lower biodiversity, does not seem to affect ecosystem services. We acknowledge that a comparison with the ecosystem services provided by undisturbed mangrove could have been useful to assess the impact of degradation against a 'control forest', but this was not possible in the study area, where all mangrove forests have been disturbed.

6. Conclusion

This paper has explored the effects of mangrove exploitation on the biodiversity of mangrove, including species composition, species dominance, diversity, tree density, frequency, coverage, and the diameter of stems as well as the subsequent relationship to ecosystem services in South Sulawesi. High dependence on and varied utilization of mangrove forests by communities in past decades ~~has~~ have led to a decrease in biodiversity. *Rhizophora* sp. is the predominant species and also the one most commonly exploited by local communities because it yields greater economic benefits than other species. In an effort to further exploit the mangrove forest, projects that involve communities, government, and NGOs have widely replanted *Rhizophora* sp. Mangrove restoration projects have so far focused on a low diversity of species to satisfy forest production and economic interests. Nonetheless, despite the observed deterioration in biodiversity, the mangrove habitat in South Sulawesi is still able to deliver provisioning ecosystem services and social and economic benefits to the communities and state.

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Acknowledgements

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Table 1. Distribution and change of true mangrove species on the main islands of Indonesia.

No.	Location	Period of study	Number of species	Change	References
1	Java Island	1993	28	-18	Kusmana,1993
		2006	10		Suryono, 2006
2	Sumatera	1993	27	-10	Kusmana,1993
	Island	2008	17		Onrizal and Kusmana, 2008
3	Kalimantan	1993	25	-11	Kusmana,1993
	Island	2012	14		Ardiansyah et al. 2012
4	Sulawesi	1993	27	-9	Kusmana,1993
	Island	1994	18		Nurkin, 1994
5	Maluku	1993	28	0	Kusmana,1993
	Island	2012	28		CRITC-PPO LIPI, 2012
6	Papua	1993	29	-16	Kusmana,1993
	Island	2003	13		Kusmana et al. 2003

Table 2. Number of individual mangrove counts recorded.

Growth level	Sampling site										Sub Total	%
	I	II	III	IV	V	VI	VII	VII	IX	X		
Tree	44	79	37	83	0	58	63	27	48	69	508	~~27.46~~ 27
Sapling	196	86	128	25	63	23	69	60	35	53	738	~~39.89~~ 40
Seedling	49	48	42	38	23	36	102	112	39	115	604	~~32.64~~ 33
Total	289	213	207	146	86	117	234	199	122	237	1850	100

Table 3. List of mangrove species recorded.

No	Name of Family	Name of Species	Local Name	Sampling Site									
				I	II	III	IV	V	VI	VII	VIII	IX	X
1	*Avicenniaceae*	*Avicennia alba* Bl.	*Api-api*	+	+	+	+	-	-	-	+	-	+
2	*Rhizophoraceae*	*Bruguiera gymnorrhiza* (L) Lam.	*Tanjang*	-	-	-	-	-	+	+	+	+	+
3	*Rhizophoraceae*	*Ceriops tagal* (-Pers.) C.B.Rob.	*Tengar*	-	-	-	+	-	-	+	+	-	-
4	*Euphorbiaceae*	*Excoecaria agallocha* L.	*Buta-buta*	-	-	-	-	-	-	+	-	+	-
5	*Combretaceae*	*Lumnitzera racemosa* Willd.	*Api-api balah*	-	-	-	-	-	-	-	+	-	+
6	*Arecaceae*	*Nypa fruticans* Wurmb	*Nipa*	-	-	-	-	-	+	-	-	-	-
7	*Rhizophoraceae*	*Rhizophora apiculata* Bl.	*Bakau*	+	+	+	-	-	+	+	-	-	-
8	*Rhizophoraceae*	*Rhizophora mucronata* Lam.	*Bakau*	+	+	+	+	+	+	+	+	+	+
9	*Rhizophoraceae*	*Rhizophora stylosa* Griff.	*Bakau*	-	+	-	-	+	-	-	-	-	+
10	*Sonneratiaceae*	*Sonneratia alba* Sm.	*Pedada*	+	+	+	-	-	-	+	+	-	+
		Number of species =		4	5	4	3	2	4	6	6	3	6

+ : present; - : not present

Table 4. Importance Value Index (IVI) of mangrove species.

	Tree								
No.	Mangrove Species	D	RD	F	RF	C	RC	IVI	Rank
1	*Avicennia alba* Bl.	0.0103	6.102	0.367	13.415	0.9575	15.282	34.7995	III
2	*Bruguiera gymnorrhiza* (L) Lam.	0.0087	5.118	0.1	3.658554	0.7163	11.433	20.21	VI
3	*Ceriops tagal* (Pers.) C.B.Rob.	0.007	4.134	0.167	6.0976	0.3464	5.5296	15.766	V
4	*Excocaeria agallocha* L.	0.0047	2.7563	0.067	2.439	0.216	3.448	8.64299	X
5	*Lumnitzera racemosa* Willd.	0.0033	1.9692	0.067	2.439	0.3191	5.0927	9.5003010	IX
6	*Nypa fruticans* Wurmb	0.0157	9.252	0.067	2.439	0.0734	1.1712	12.8623	VIII
7	*Rhizophora apiculata* Bl.	0.016	9.449	0.367	13.415	0.6738	10.7541	33.6174	IV
8	*Rhizophora mucronata* Lam.	0.076	4445.88	0.8	29.268	1.3241	21.133	95.284	I
9	*Rhizophora stylosa* Griff.	0.0163	9.64610	0.367	13.415	0.4972	7.93548	30.9961	V
10	*Sonneratia alba* Sm.	0.0113	6.6937	0.367	13.415	1.1416	18.221	38.329	II
	Total	0.1693	100	2.733	100	6.2654	100	300	
	Sapling								
No.		D	RD	F	RF	IVI	Rank		
1	*Avicennia alba* Bl.	0.0183	7.453	0.367	13.415	2021.867	IV		
2	*Bruguiera gymnorrhiza* (L) Lam.	0.0197	7.9958	0.1	3.658554	11.65312	VI		
3	*Ceriops tagal* (Pers.) C.B.Rob.	0.009	3.6594	0.167	6.0976	9.756110	VII		
4	*Excocaeria agallocha* L.	0.0063	2.5753	0.067	2.439	5.0136	IX		
5	*Lumnitzera racemosa* Willd.	0.0067	2.713	0.067	2.439	5.1491	VIII		
6	*Nypa fruticans* Wurmb	0.0027	1.084	0.067	2.439	3.5234	X		
7	*Rhizophora apiculata* Bl.	0.0483	19.6520	0.367	13.415	33.062	II		
8	*Rhizophora mucronata* Lam.	0.091	36.9937	0.8	29.268	66.26	I		
9	*Rhizophora stylosa* Griff.	0.018	7.317	0.367	13.415	20.7321	V		
10	*Sonneratia alba* Sm.	0.026	10.571	0.367	13.415	23.9844	III		
	Total	0.246	100	2.733	100	200			
	Seedling								
No.		D	RD	F	RF	IVI	Rank		
1	*Avicennia alba* Bl.	0.0243	12.09	0.367	13.415	25.5016	II		
2	*Bruguiera gymnorrhiza* (L) Lam.	0.026	12.9113	0.1	3.658554	16.57217	VI		

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3	*Ceriops tagal* (Pers.) C.B.Rob.	0.0137	6.7887	0.167	6.0976	12.8863	VII
4	*Excocaeria agallocha* L.	0.0087	4.305	0.067	2.439	6.74377	VIII
5	*Lumnitzera racemosa* Willd.	0.006	2.983	0.067	2.439	5.4192	IX
6	*Nypa fruticans* Wurmb	0.004	1.9872	0.067	2.439	4.4258	X
7	*Rhizophora apiculata* Bl.	0.0237	11.7512	0.367	13.415	25.17	III
8	*Rhizophora mucronata* Lam.	0.0603	29.9730	0.8	29.268	59.235	I
9	*Rhizophora stylosa* Griff.	0.0123	6.126	0.367	13.415	19.5420	V
10	*Sonneratia alba* Sm.	0.0223	11.09	0.367	13.415	24.5075	IV
	Total	0.2013	100	2.733	100	200	

D = Density; RD = Relative of Density; F = Frequency; RF = Relative of Frequency; C = Coverage; RC= Relative of Coverage; IVI = Importance Value Index.

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Table 5. Diversity Index (H'D) of mangrove forest.

Growth Level	Index	Sampling site									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Tree	H'D	1.370.09	1.570.06	1.280 .11	1.050. 04	--	1.30 0.07	1.68 0.10	1.70 0.22	1.06 0.06	1.72 0.09
Sapling	H'D	1.340.02	1.560.06	1.220 .03	1.040. 12	0.670. 03	1.37 0.17	1.77 0.09	1.76 0.10	1.09 0.09	1.73 0.11
Seedling	H'D	1.370.08	1.580.10	1.300 .10	1.030. 08	0.620. 09	1.36 0.11	1.74 0.06	1.72 0.05	1.06 0.08	1.74 0.05

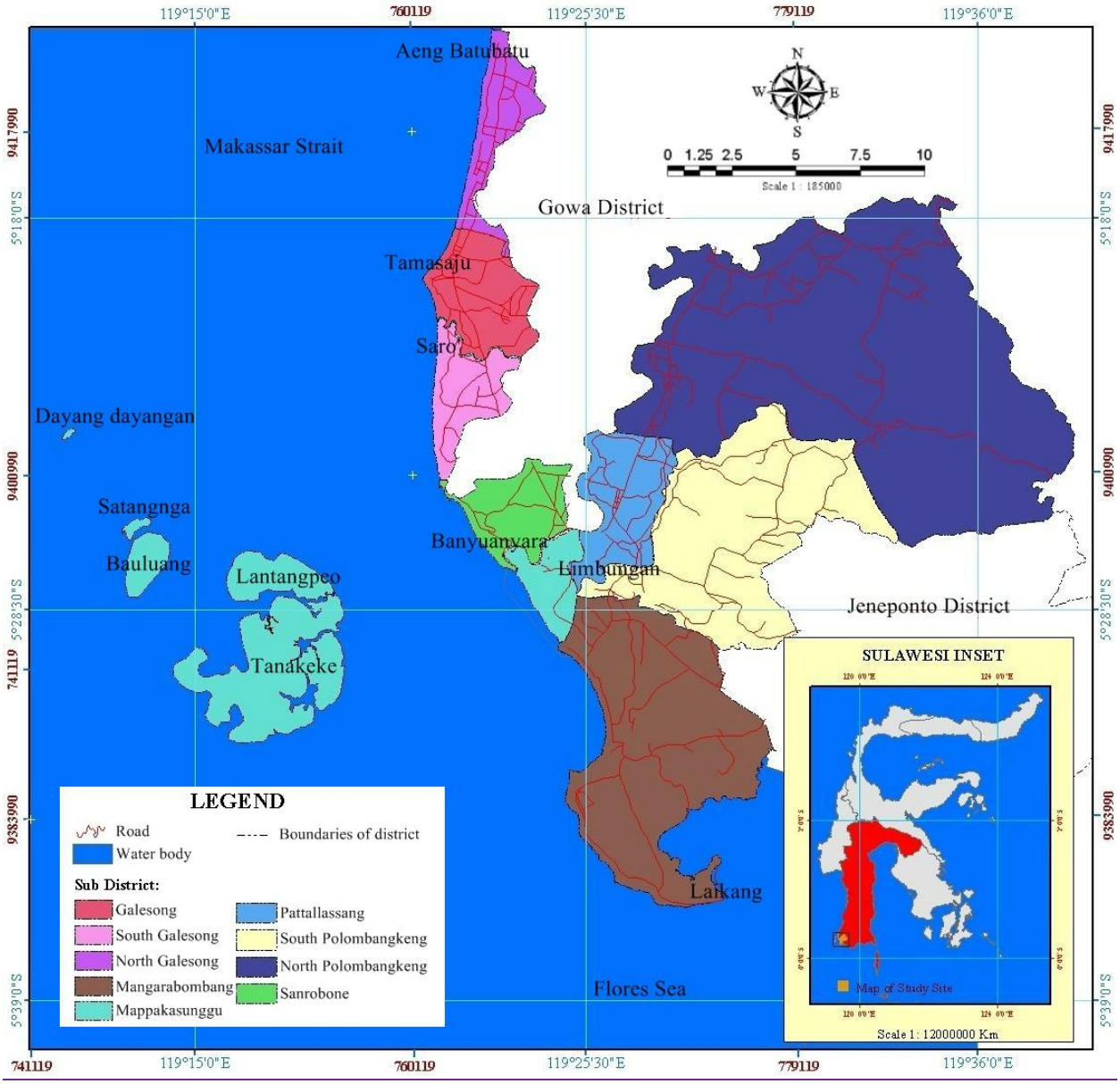
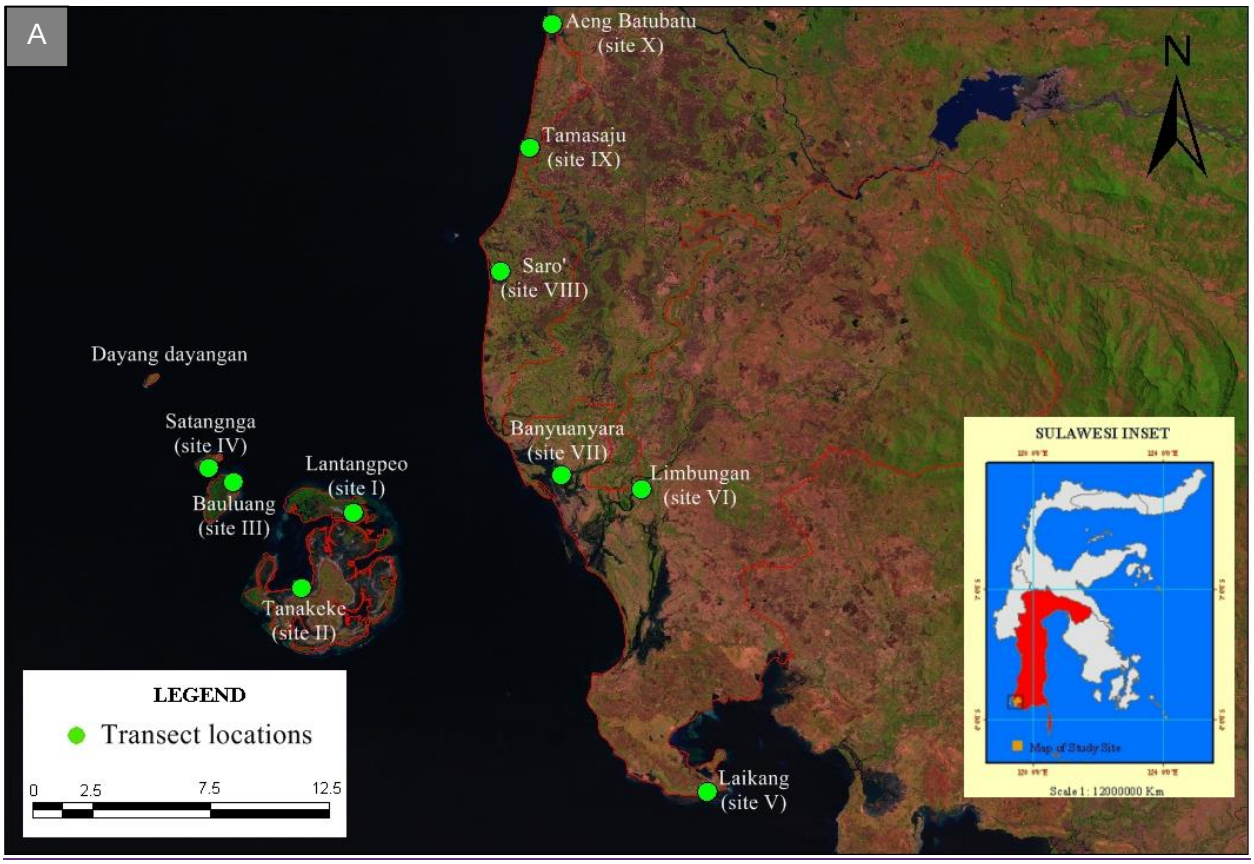


Figure 1. Map of the Takalar district study area, South Sulawesi.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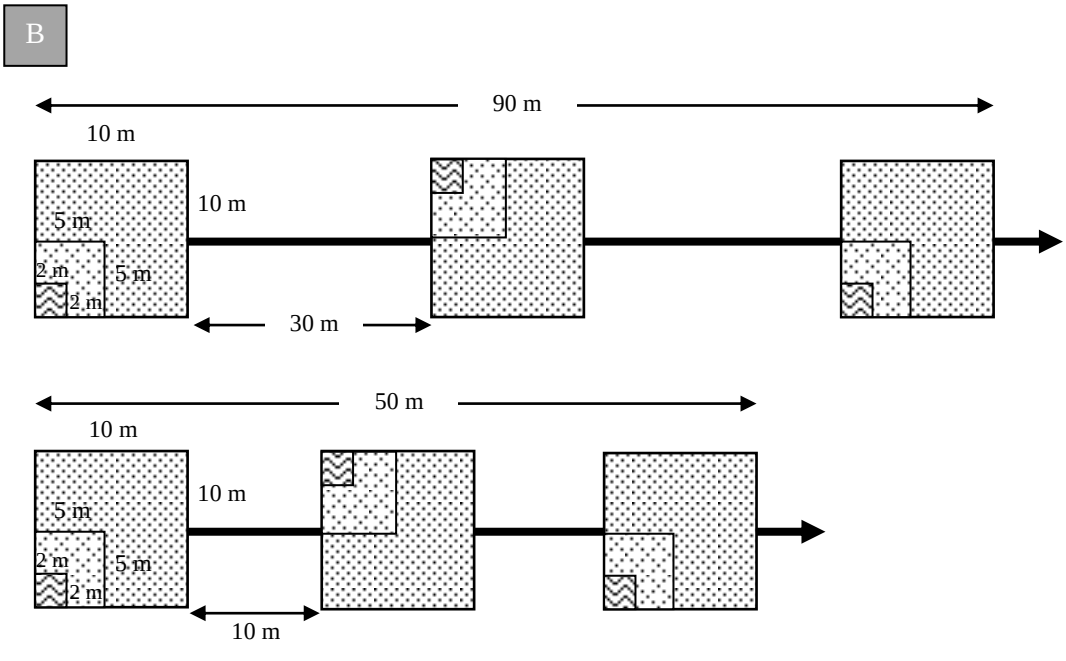
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Figure 2. (A) Locations of transect measurements. (B) Design of the line plots applied for each transect.

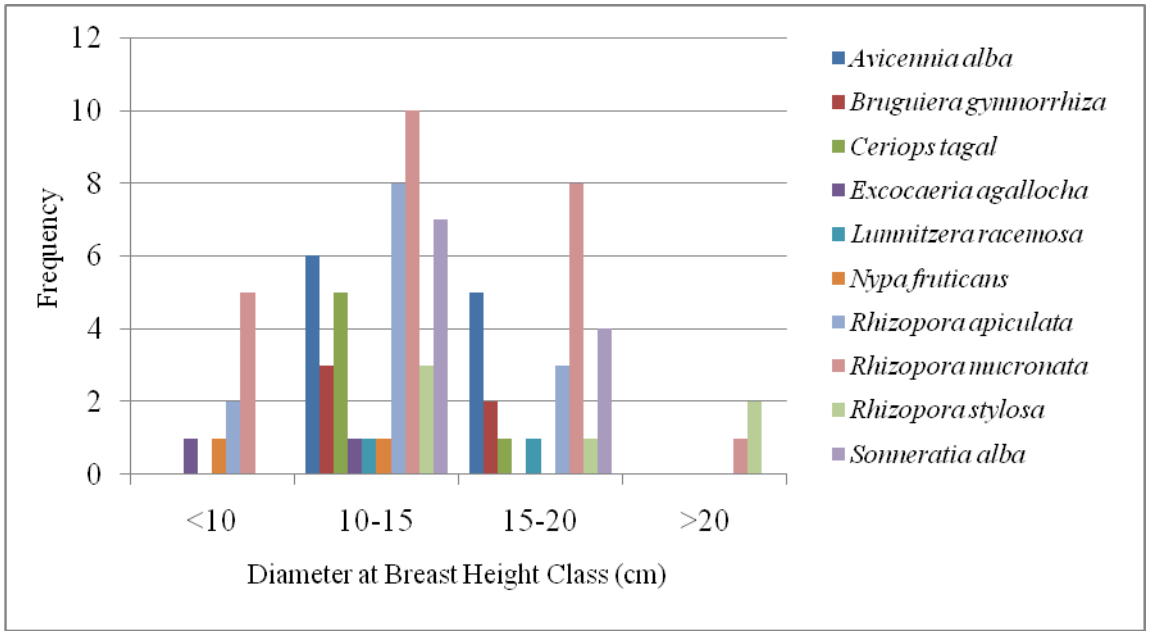

Figure 3. Frequency distribution of diameter size classes of mangrove species

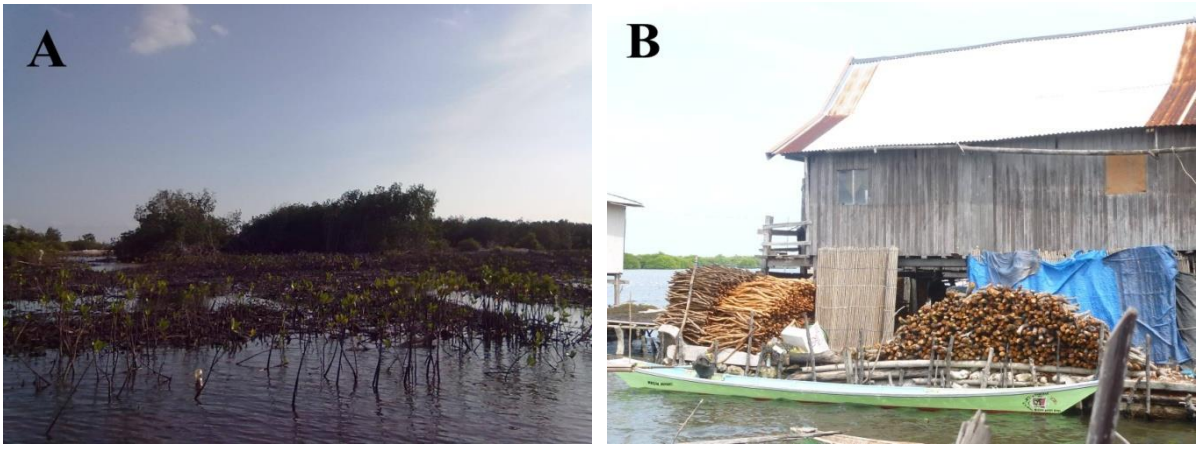

Figure 4. (A) Mangrove area destruction caused by wood cutting on Satangnga Island and (B) firewood production of *Rhizophora sp*. on Lantangpeo Island.

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To the authors,

Please carefully consider my further points regarding your study. I very much like what you have done, and thank you for taking on board my initial comments. If you accept my considerations (below), I will be happy for this manuscript to be published.

Best wishes…

Line 36 – 41: Mangrove forests constitute important ecosystems that provide a wide range of services and products for coastal communities, including protection from storms and large waves (Danielsen et al. 2005), preventing coastal erosion and inland intrusion of salt water and pollutants, providing nursery, feeding, and spawning grounds for many marine organisms, and providing products such as fuel wood, charcoal, medicine, and timber (Chang-yi et al. 1997; Wang et al. 2003, Giesen et al. 2007; Ong and Gong, 2013). **All one sentence, would be easier to read if made shorter, E.g. below:**

"…Mangrove forests provide a wide range of services and products for coastal communities including protection from storms and large waves (Danielsen et al. 2005), prevention from coastal erosion and pollutants, nursery, feeding, and spawning grounds and providing products such as fuel wood, charcoal, medicine, and timber (Chang-yi et al. 1997; Wang et al. 2003, Giesen et al. 2007; Ong and Gong, 2013)."

Line 46 – 50: A little bit confused. Perhaps try this (below):

"…With eighty percent of all true mangrove species, the most biodiverse mangrove species diversity in the world is found in the Indo-Pacific region (Saenger et al. 1983). Indonesia alone contains seventy-two percent of the world's true mangroves (Kusmana, 1993), which has the highest mangrove diversities in the world."

Line 51-52: The high value of mangrove forests, however, has also generated very high levels of exploitation and deforestation of mangroves is widespread.

***Too much information in the above sentence. Try**, " The high value of mangrove forests has generated high levels of exploitation and deforestation. This impact is reducing mangrove forests productivity globally (Duke et al. 2007)" – Ref: Norm Duke, A World without Mangroves, 2007.

Line 54-57: Indonesia, the country with the largest mangrove area in the world, lost 1.2 million hectares in the same period, or about one quarter of the mangrove area, with about 3.2 million hectares of mangrove forest remaining (Bakosurtanal, 2009). ****TEXT in red = you have already said this. <u>Do not repeat</u>.**

Try this: Indonesia lost 1.2 million hectares in the same period, or about one quarter of the mangrove area, with only 3.2 million hectares of mangrove forest remaining (Bakosurtanal, 2009).

Line 60-64: Walters (2005) reported that wood cutting in mangroves in the Philippines caused forest structure change and altered species composition, especially at the expense of less resilient species, and mangrove forest degradation in terms of reduced biodiversity has

also been reported in Cameroon (Din et al. 2008) and Bangladesh (Iftekhar and Takama, 2008). **All one sentence, difficult to read and make sense of.**

Try this:

"…Walters (2005) reported that wood cutting in Philippine mangroves created the change in forest structure and altered species composition. To add, reduced mangrove biodiversity has also been reported in Cameroon (Din et al. 2008) and Bangladesh (Iftekhar and Takama, 2008) due to forest harvesting."

Line 68-70: Similarly, in the Segara Anakan Lagoon, Central Java, wood cutting and high sedimentation rates from rivers inhibited the growth of some mangrove species (*Sonneratia* sp., *Rhizophora* sp. and *Bruguiera* sp.) compared to the 1980s (Hinrichs et al. 2008).

****NOTE:** I see what the point is here, but you make no prior reference of what condition the mangrove forests were like in the 1980s (**text highlighted in red**).

Line 79-81: There are indications that reduced biodiversity of ecosystems may negatively affect a range of provisioning, regulating, cultural and supporting ecosystem services (Harrison et al. 2014; Millennium Ecosystem Assessment, 2005). **NO, *see below*:**

(Millennium Ecosystem Assessment, 2005; Harrison et al. 2014)

Line 87-90: It is not in all cases evident whether high biodiversity is required for sustaining a high level of ecosystem services or whether most of the ecosystem services can be provided by low diversity (Cameron, 2002; Mertz et al. 2007). **Slightly confused, see below:**

"…It is not clear whether high biodiversity is required for sustaining a high level of ecosystem services or whether most of the ecosystem services can be provided by low diversity (Cameron, 2002; Mertz et al. 2007).

Line 91: **Remove,** "Hence, in this paper…". Begin sentence with, "We investigated the effects…"

Line 96: Italicise "Nypa", "*Nypa* palm…"

Line 101-103: The chosen study area in Indonesia – Takalar District, South Sulawesi – is therefore considered an appropriate case as it represents one of the most mangrove rich regions where this forest type is under strong pressure from exploitation. **Try this:**

"…The field work was conducted in Indonesia, the Takalar District, South Sulawesi, one of the most mangrove rich regions. These forests are under strong pressure from anthropogenic exploitation."

Line 123: "Nypa" – italicise

Line 127: **remove** "…quite"

Line 135-137: The biodiversity of mangrove forests including species composition and structure, was measured using a compass, clinometers, a large knife, measuring tape, a tally

counter, plastic rope, a tally sheet, a camera, and a reference book for identifying mangrove species. **How did you measure the biodiversity of mangrove forests using a large knife and camera?**

Line 163-167: Questionnaires were administered to 100 163 households, who were selected by a Purposive Sampling method. Information was collected on the respondents' understanding of mangrove functions and benefits, details of their use of mangrove forests, such as forest type and age as well as frequency of use, the amount earned per utilization and the operation costs involved. **ALL ONE SENTENCE – please shorten or break up. ***PLEASE NOTE: Species authority need only be mentioned once at the beginning**, e.g. "*Rhizophora mucronata* Lam" …but thereafter no need to repeat, "*Rhizophora mucronata*"

Line 231-234: The IVI showed that *Rhizophora mucronata* Lam. 231 was the dominating species at all levels of regeneration, followed by *Sonneratia alba* Sm., whereas for saplings and seedlings, *Rhizophora apiculata* Bl. and *Avicennia alba* Bl. dominated, respectively (Table 4). **Rewrite: see below…**

"...Rhizophora mucronata Lam. 231 was the dominating species at all levels of regeneration, followed by *Sonneratia alba* Sm., whereas for saplings and seedlings, *Rhizophora apiculata* Bl. and *Avicennia alba* Bl. dominated, respectively (IVI, Table 4)."

Line 258-260: The species composition of mangroves in the study area consisted of ten species, all of which are well known in the region of Indonesia (FAO, 2007) and belong to what is taxonomically known as 'true mangrove species' (Tomlinson, 1986**). **NOTE: Not relevant! We know you recorded 10 species (please do not repeat yourself) AND we know they are true mangroves. REMOVE THIS please.**

Line 275-276: Furthermore, the number of true mangrove 275 species was also lower than what was found in a number of other sites in Southeast Asia**. See below,**

"…Furthermore, the number of true mangrove species was less than those recorded from a number of other sites in Southeast Asia**."**

Line 276-280: These include Balok River Pahang of Malaysia (12 species, Rozainah and Mohamad, 2006), the east coast of North Sumatra (17 species, Onrizal and Kusmana, 2008), Aurora, Philippines (18 species, Rotaquio et al. 2007), Sundarbans Delta, Eastern India (24 species, Barik and Chowdhury, 2014), and Segara Anakan Lagoon in Central Java of Indonesia (26 species, Hinrichs et al. 2008). ****NOTE: why have you bracketed the number of species found?**

Line 281: Remove, "…in the study area"

Line 287-288: Remove, "..in our study area"

Line 289-290: This pattern is similar to what occurred on the east coast of North Sumatra (Onrizal and Kusmana, 2008). ****NOTE: Needs expanding. What occurred in North Sumatra???**

*****NOTE: "Malik et al. in review" …You use this a lot! Has this manuscript been accepted? If not, you need to be very careful here…**

Line 378-381: ALL ONE SENTENCE – make shorter please.

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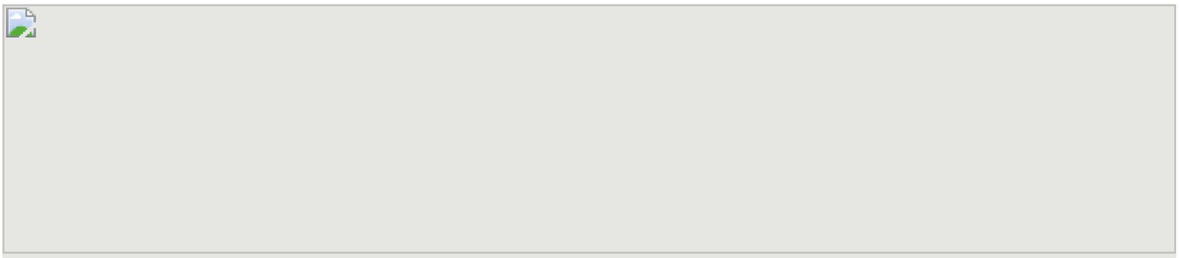

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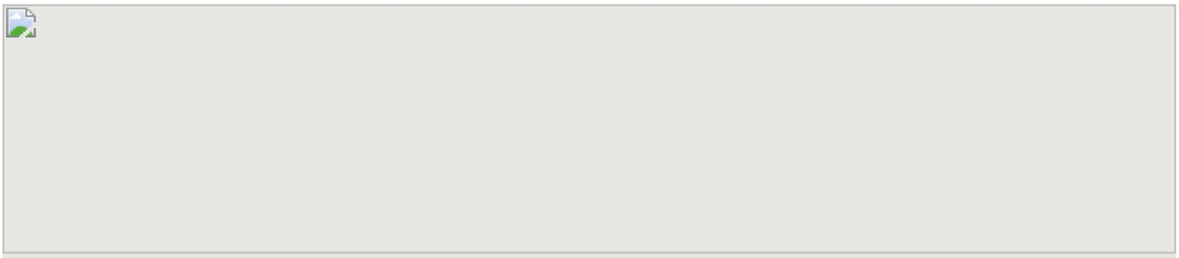

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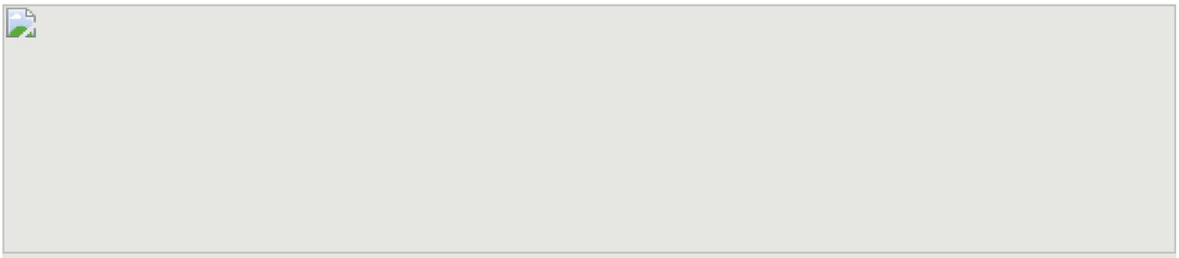

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