

1 Using iNaturalist observations to detect disease in Red Mangroves (*Rhizophora mangle*)

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**Abstract:**

Detection of disease over broad spatial scales is important to managing the spread of many diseases. One way to do this is to work with citizen scientists to collect data over broad spatial and temporal scales. Citizen science observations are becoming more widely available through web and app interfaces such as iNaturalist.org. iNaturalist.org provides passive sampling of organisms through photographs with a geolocation. These observations are often used to examine biodiversity and species monitoring, but, disease detection is also possible. Here, I demonstrate the utility of using iNaturalist.org observations of red mangrove to detect foliar disease symptoms such as lesions. I downloaded observations of red mangrove from iNaturalist.org, filtered them and examined images for foliar disease symptoms. Out of 153 filtered images, I found that 42% showed no signs of foliar disease while 58% did show foliar disease symptoms. I also found that observations of red mangrove were recorded from 15 countries in total, with 11 countries having at least one observation with foliar disease symptoms present. While small, this study demonstrates the utility of using resources such as iNaturalist.org to obtain preliminary disease observations which can be used to further focus in person disease surveys and sampling.

## Introduction:

Disease detection over broad spatial scales is often critical to managing the development and spread of many important agricultural and forest pathogens and pests. One way to increase disease detection is to involve citizens in the collection of this data. Recently, citizen scientists helped document and track the spread of Sudden Oak Death in California by learning how to identify and survey oak trees and alternative hosts for the pathogen (Meentemeyer et al. 2015; Rizzo & Garbelotto 2003). Citizen scientists that participated in the Sudden Oak Death project attended training sessions and then went into the field to detect and collect samples of the pathogen. Given the severity of this disease, this approach ensures citizen scientists collect the correct data. However, time and other resources are spent training and interacting with participants which may not be possible for disease monitoring of less severe diseases.

Another way to detect diseases with citizen scientists is through more passive sampling such as photographs with a geolocation. One such resource to use for this method is iNaturalist (<https://www.inaturalist.org/>). iNaturalist is a crowdsourced database of natural history observations. Photographs are typically included in observations so that observations can be validated (Freitag et al. 2016). Often, iNaturalist is used as a tool to record the biodiversity of species (Palumbo et al. 2012; Pimm et al. 2015) . However, observations from iNaturalist could be used for much more such as species monitoring and detection of specific diseases and/or pests. For example, as of September 2017, there are 17 projects that ask contributors to focus images on detection of specific diseases and pests. Here, I demonstrate the utility of using general iNaturalist observations (i.e., not collected for a specific project) to detect foliar disease symptoms in mangrove forests.

## Materials and Methods:

iNaturalist observations were downloaded in April 2017. “Red mangrove” was used as the search term. Observations were individually examined to confirm *R.mangle* was correctly identified. Images that were low resolution, taken at too far of a distance, or did not include leaves in the image were excluded. Following filtering of observations, images were examined for foliar disease symptoms. The symptoms focused on were lesions (necrotic tissue on the leaf). Only images that had leaves present with lesions were counted as having disease symptoms. We did not consider the number of leaves in the images with lesions since we simply wanted to detect the presence or absence of disease in the images.

## Results and Discussion:

I found that 16 out of the original 405 observations were not truly *R.mangle*. Of the remaining 389 observations that were *R.mangle*, 236 images were excluded leaving a total of 153 observations that were viable (i.e., could zoom to investigate leaves). The 153 observations were from 15 countries (Table I). 42% (n=64) of observations showed no disease symptoms and 58% (n=89) did show disease symptoms. Overall, disease symptoms were observed in 11 countries (Table I). Mexico (n=53) and the United States (n=70) had the greatest number of observations recorded with 49% and 70% of observations having disease, respectively.

Overall, I found that iNaturalist observations of *R.mangle* can be used to detect foliar disease symptoms. Although I focused on foliar disease detection, iNaturalist could also be used to document canker disease on roots, scale insect outbreaks and herbivore damage (all of which

were identified in these observations). While these observations may not provide enough detail to confirm a specific type of disease, this tool provides useful baseline information that can be used to help direct more in-depth disease surveys.

To improve the use of iNaturalist observations for disease detection, specific projects could be initiated that direct contributors to what they should focus their photos on. For example, contributors could take multiple photos that capture the entire plant in addition to close-up photos of whichever part of the plant exhibits disease symptoms.

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116 Table I:

<i>Country</i>	<i>Disease</i>	<i>No . observations</i>	
<i>Aruba</i>	0	1	118
<i>Bahamas</i>	1	2	
<i>Belize</i>	3	4	119
<i>Cayman Islands</i>	0	1	
<i>Colombia</i>	1	6	120
<i>Costa Rica</i>	1	1	
<i>Cuba</i>	2	3	121
<i>Dominican Republic</i>	0	1	122
<i>Ecuador</i>	1	4	
<i>Honduras</i>	0	1	123
<i>Mexico</i>	26	53	
<i>NA</i>	2	2	124
<i>Panama</i>	1	1	
<i>Puerto Rico</i>	1	2	125
<i>Senegal</i>	1	1	126
<i>United States</i>	49	70	127

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References:

- Freitag A, Meyer R, and Whiteman L. 2016. Strategies employed by citizen science programs to increase the credibility of their data. *Citizen Science: Theory and Practice* 1.
- Meentemeyer RK, Dorning MA, Vogler JB, Schmidt D, and Garbelotto M. 2015. Citizen science helps predict risk of emerging infectious disease. *Frontiers in Ecology & the Environment* 13:189-194. 10.1890/140299
- Palumbo MJ, Johnson SA, Mundim FM, Lau A, Wolf AC, Arunachalam S, Gonzalez O, Ulrich JL, Washuta A, and Bruna EM. 2012. Harnessing smartphones for ecological education, research, and outreach. *The Bulletin of the Ecological Society of America* 93:390-393.
- Pimm SL, Alibhai S, Bergl R, Dehgan A, Giri C, Jewell Z, Joppa L, Kays R, and Loarie S. 2015. Emerging Technologies to Conserve Biodiversity. *Trends in Ecology & Evolution* 30:685-696. <https://doi.org/10.1016/j.tree.2015.08.008>
- Rizzo DM, and Garbelotto M. 2003. Sudden oak death: endangering California and Oregon forest ecosystems. *Frontiers in Ecology and the Environment* 1:197-204.