

Simulating the Interruption of Transmission on Bioko Island

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TAG Meeting
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Overview

- Premise
 - Will the PfSPZ Vaccine be sufficient to interrupt local transmission?
 - Build a simulation model of malaria transmission on Bioko Island, calibrated to geospatial maps generated using MIS data

Simulation Model Rationale

- Scenario planning
- A guide to understanding efficacy of adding new interventions
 - Can compare outcomes from many different potential plans
 - Can quantify uncertainty in different outcomes
- Carefully calibrated to data
 - Malaria Indicator Survey
 - Geospatial Maps

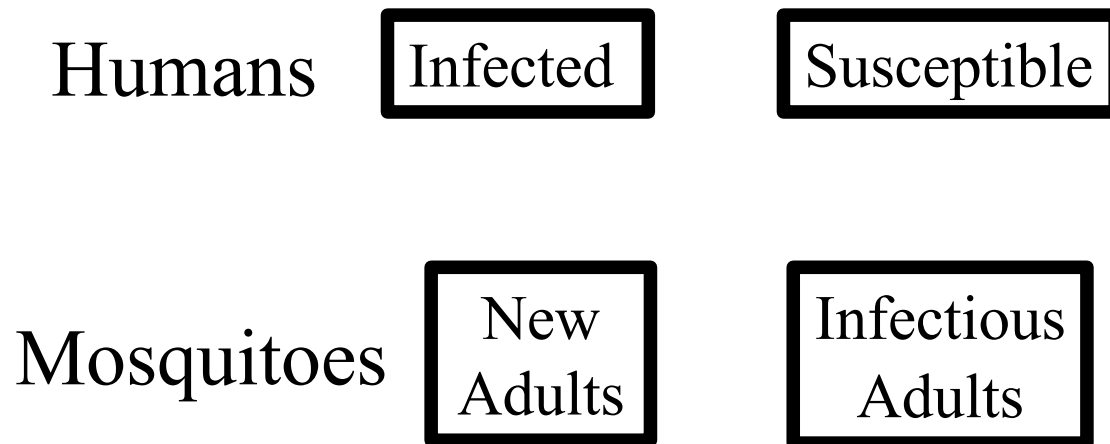
Our Model

- Based on Ross-Macdonald model
- Begin with human population

Humans **Infected** **Susceptible**

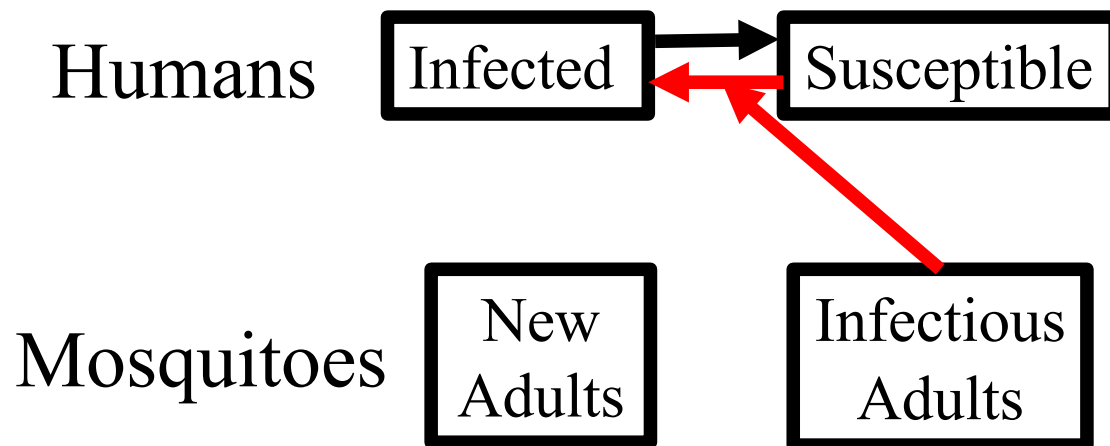
Our Model

- Add interactions with mosquito population



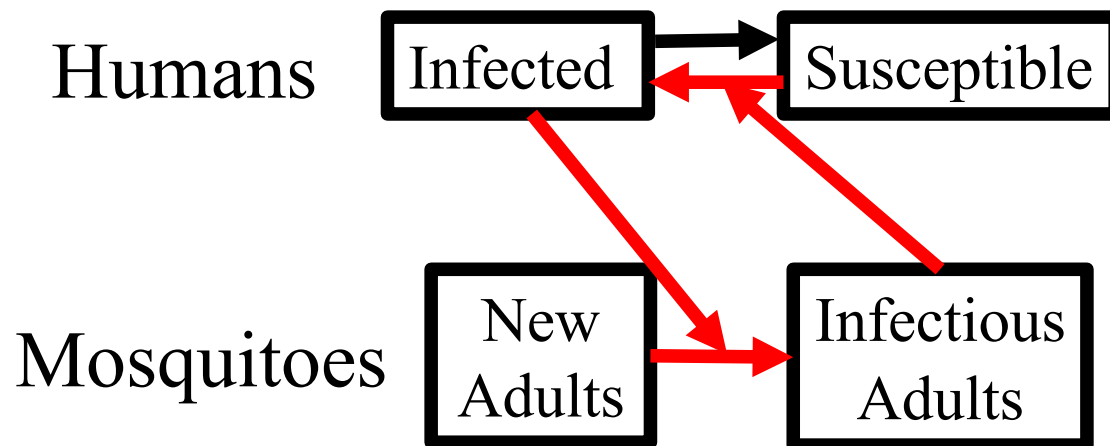
Our Model

- Infectious mosquitoes infect humans, who recover over time



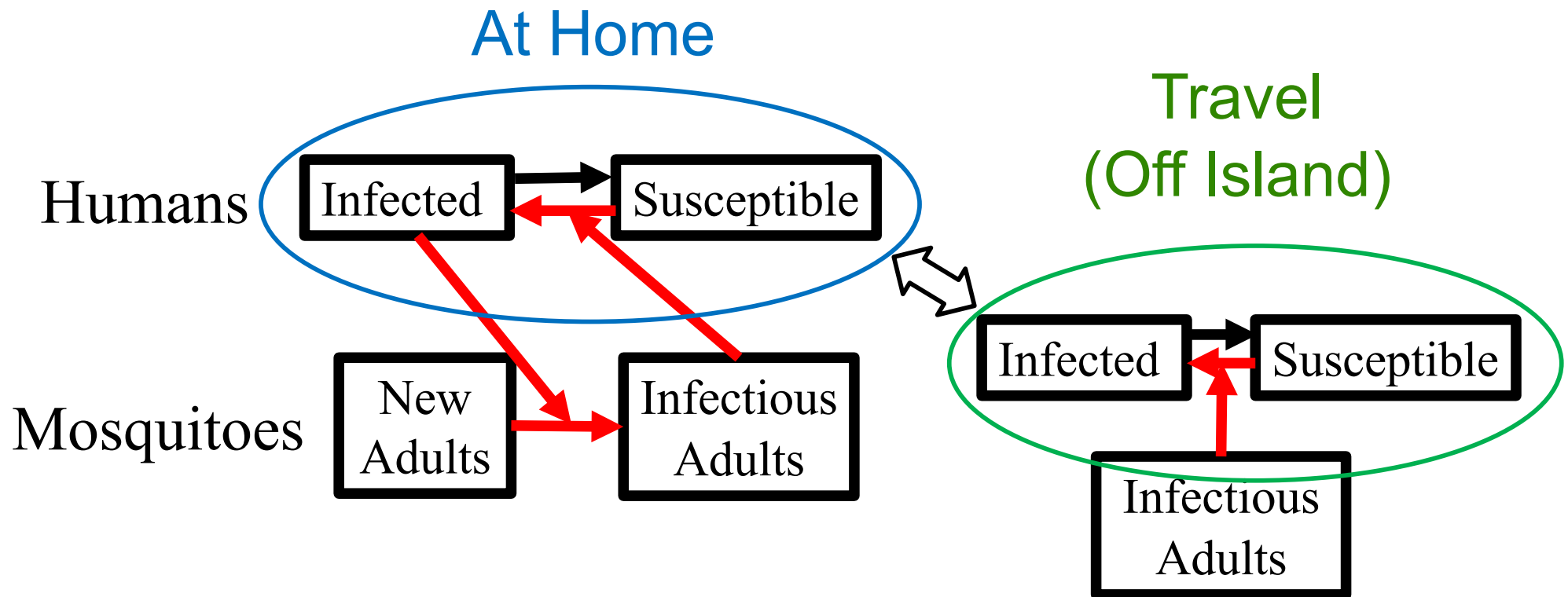
Our Model

- Humans also infect mosquitoes when they are bitten



Our Model

- Include human travel to other locations, imported infections



Model Calibration – area by area

Calibrate model for each 1km² area on Bioko Island

Features

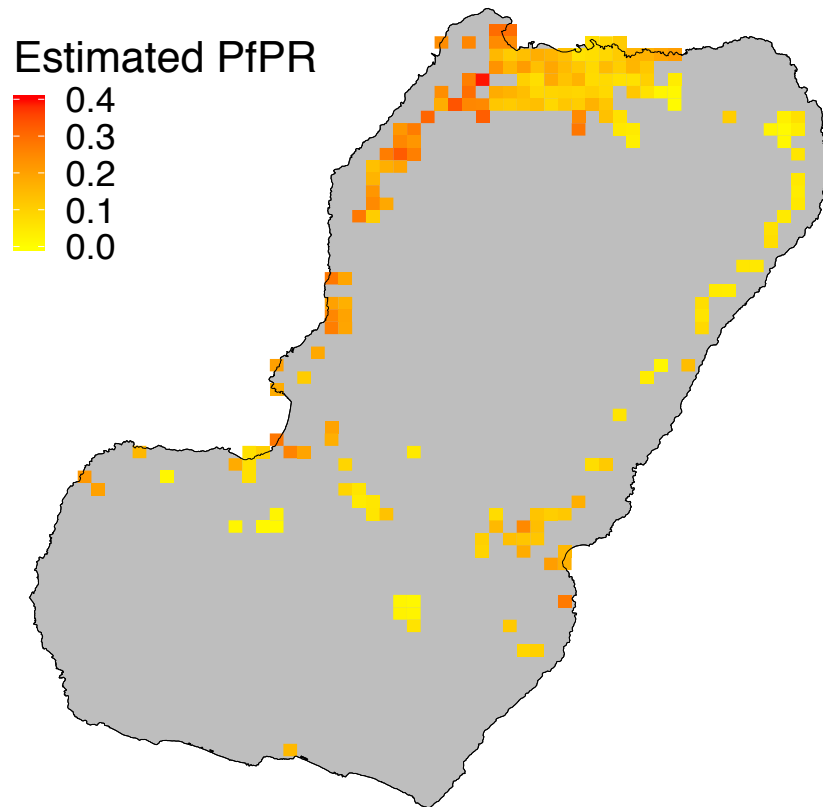
- Population
- Prevalence
- Travel frequency
- Local Transmission
- Risk while traveling

Data Inputs

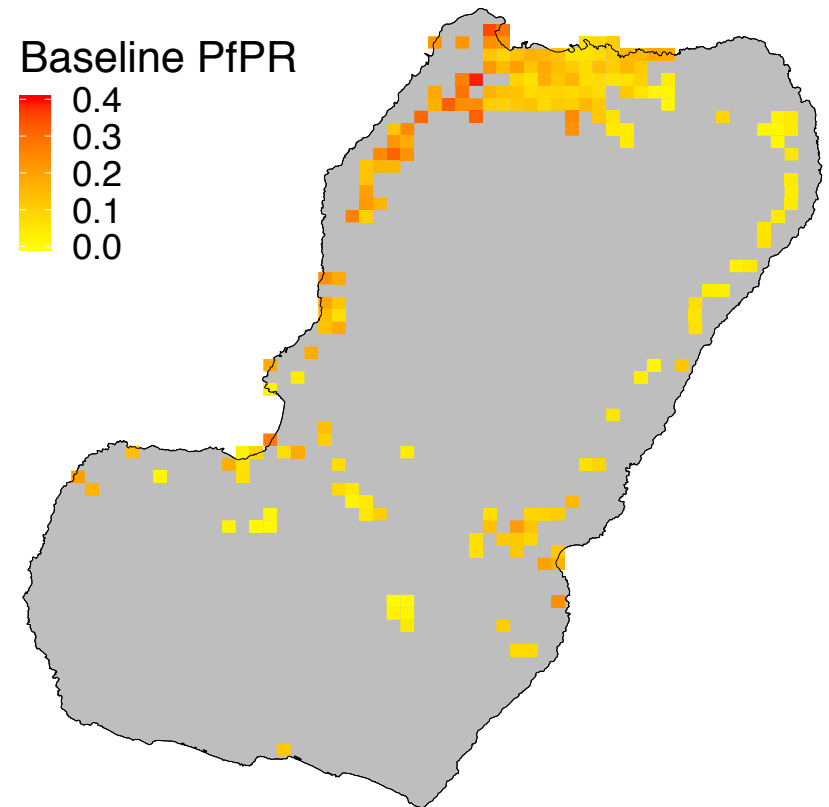
- ← Population Census
- ← Geospatial estimates, PR
- ← Geospatial estimates, travel
- ← Geospatial estimates, PR & Travel
- ← Bata PR estimate (Ncogo et al. 2015)

Model Calibration – Matching PR

**Geospatial Estimate
Mean PR**

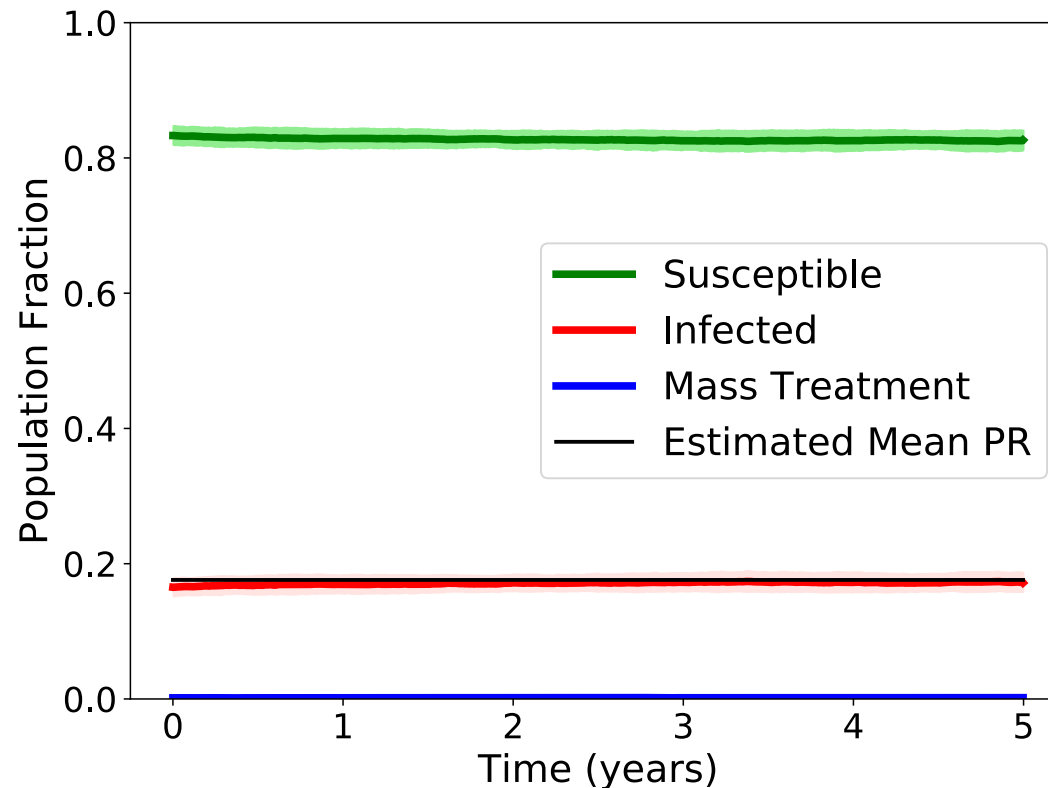
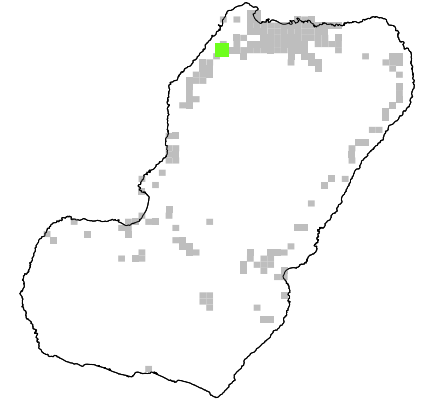


**Calibrated Model
Mean PR**



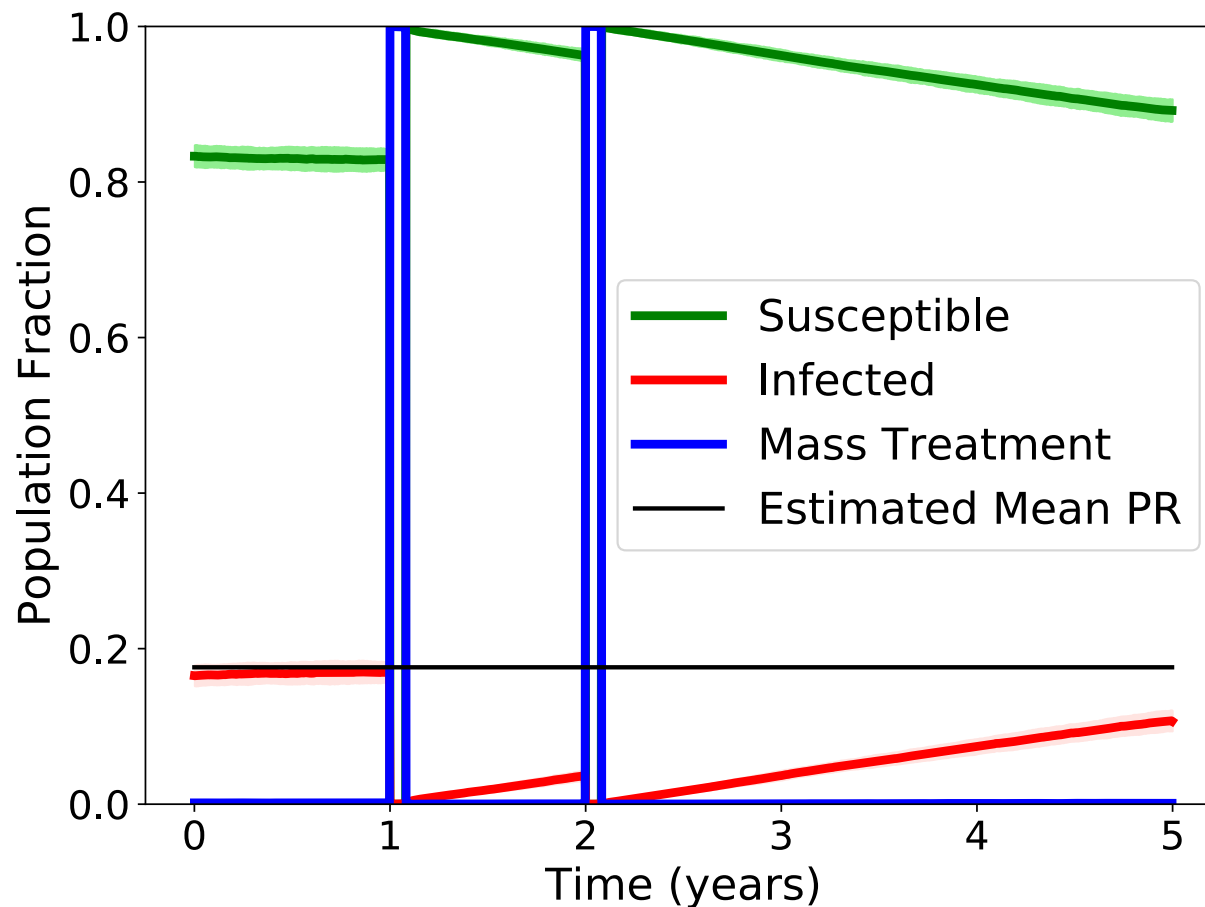
Simulation results

- Example: Basupu – 2028 people, PR = .18
- Baseline case with no interventions
- Ensemble of 100, plotting mean behavior



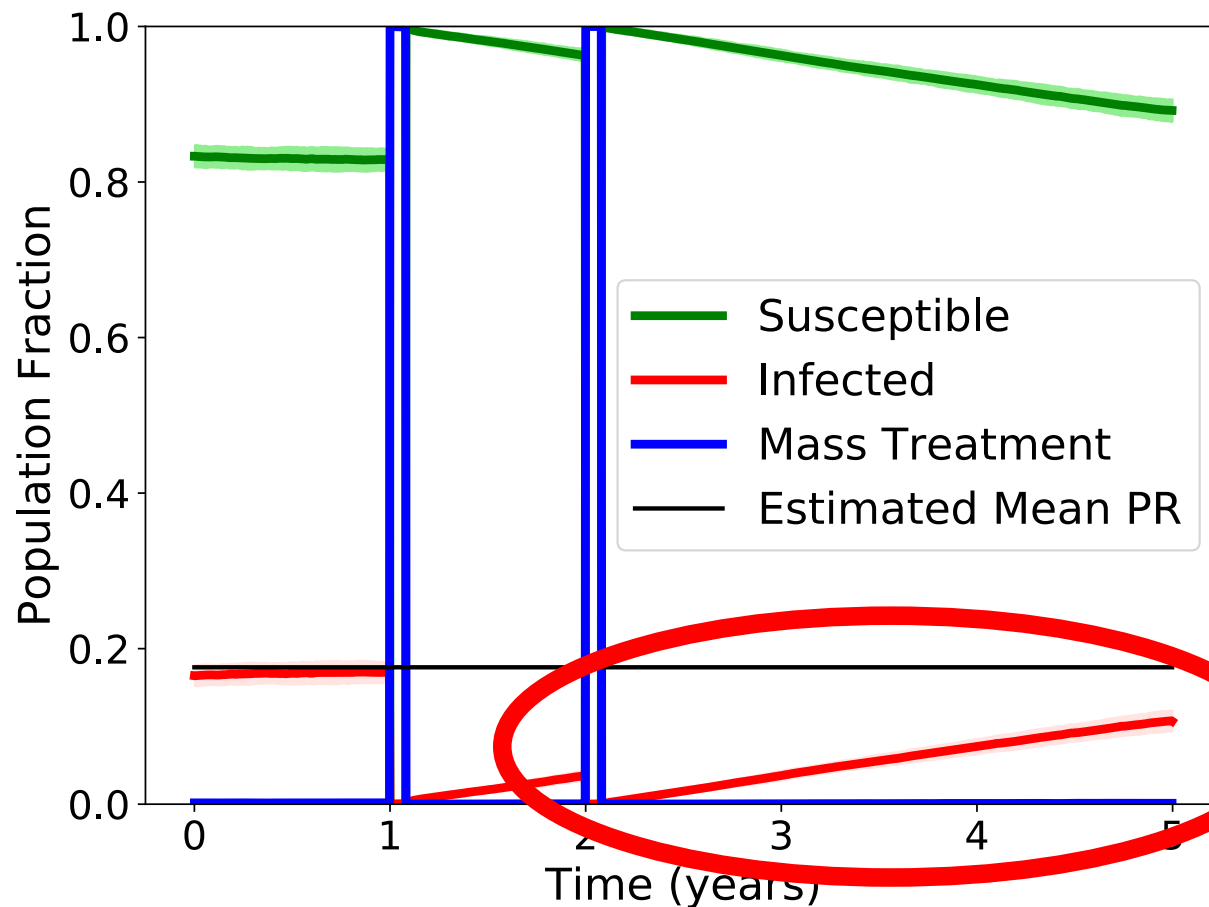
Adding Mass Treatment

- Mass treatment scheduled at start of years 2 and 3
- Clears infections, prevents new infections, lasts 30 days



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Effect of
Imported Cases

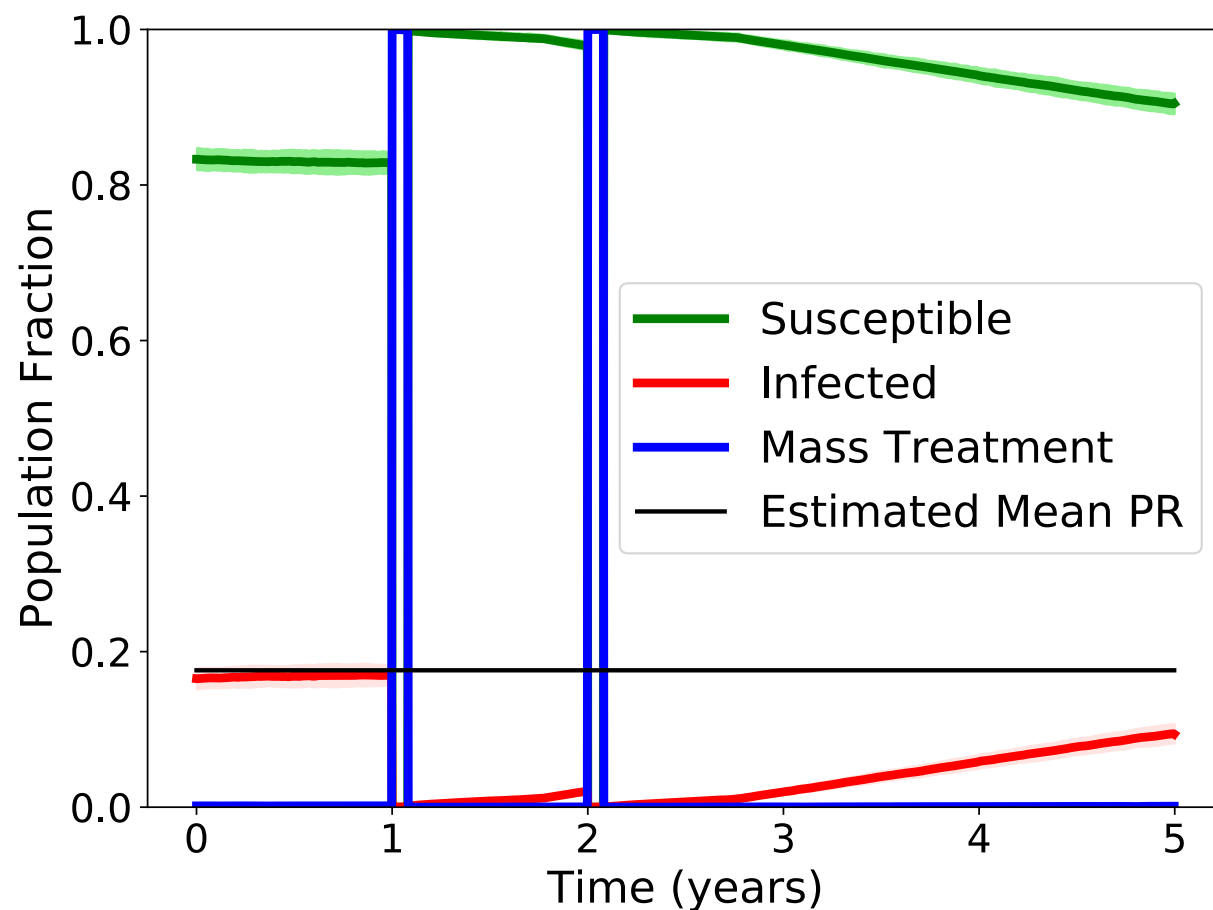


Simulated PfSPZ Vaccine

- Schedule
 - Vaccinate at years 2 and 3
 - Accompany with mass treatment
- Assumptions
 - Vaccine remains effective for 9 months
 - 100% coverage – all people vaccinated
 - 50% of recipients granted 100% personal protective efficacy

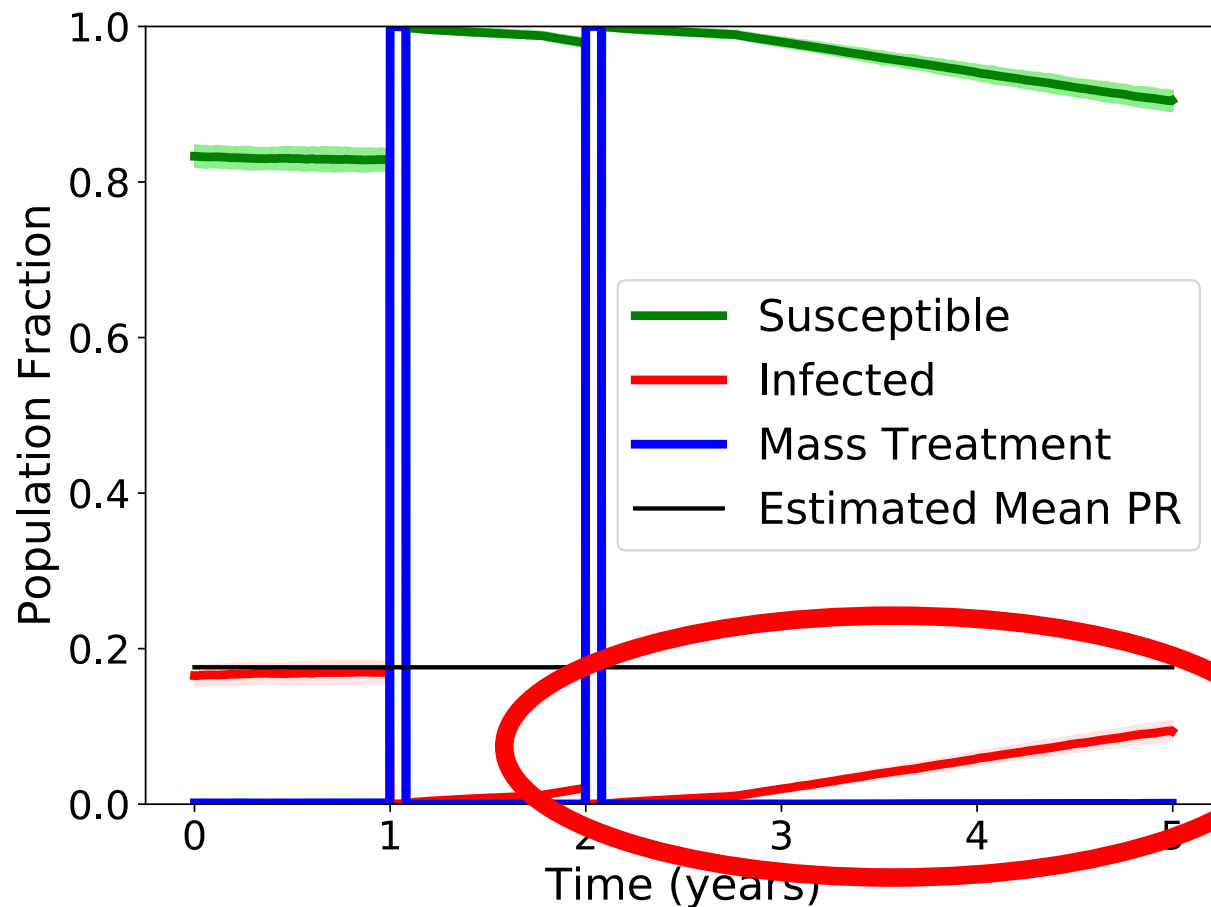
Adding Vaccination

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Adding Vaccination

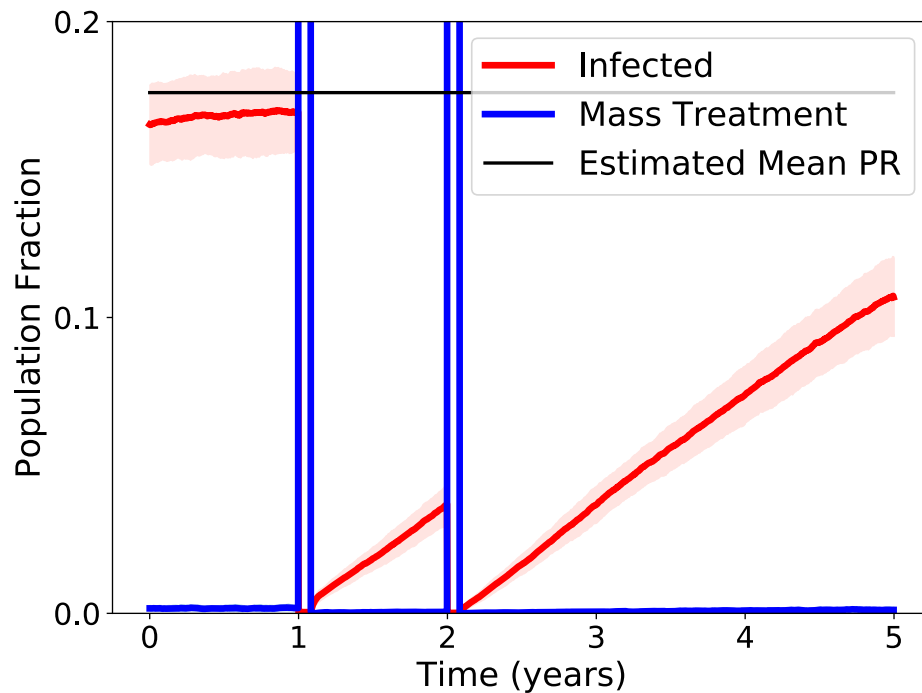
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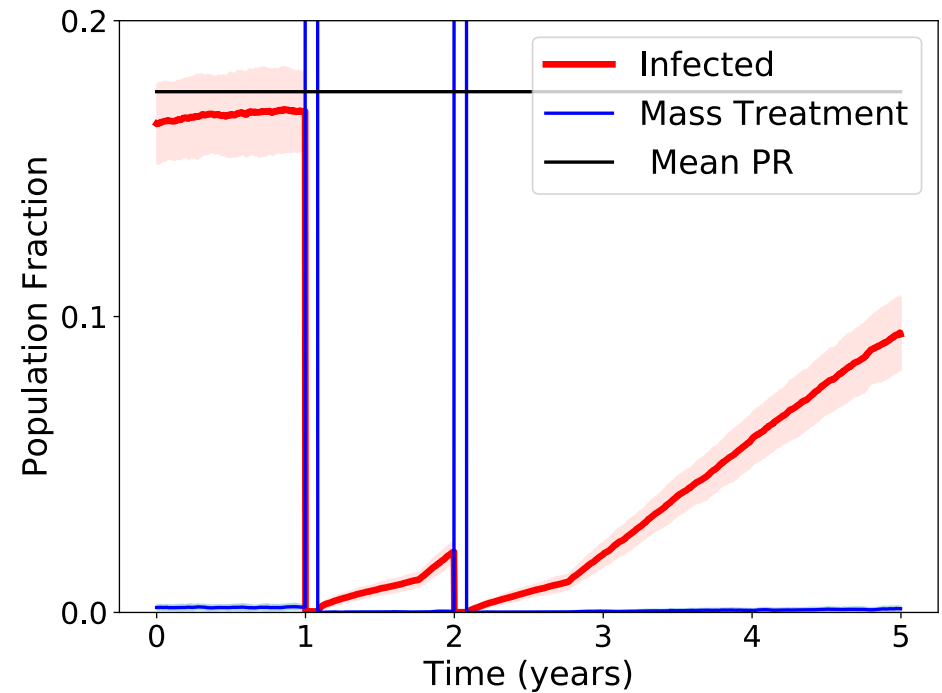
Effect of
Imported Cases

Adding Vaccination

Mass Treatment Only



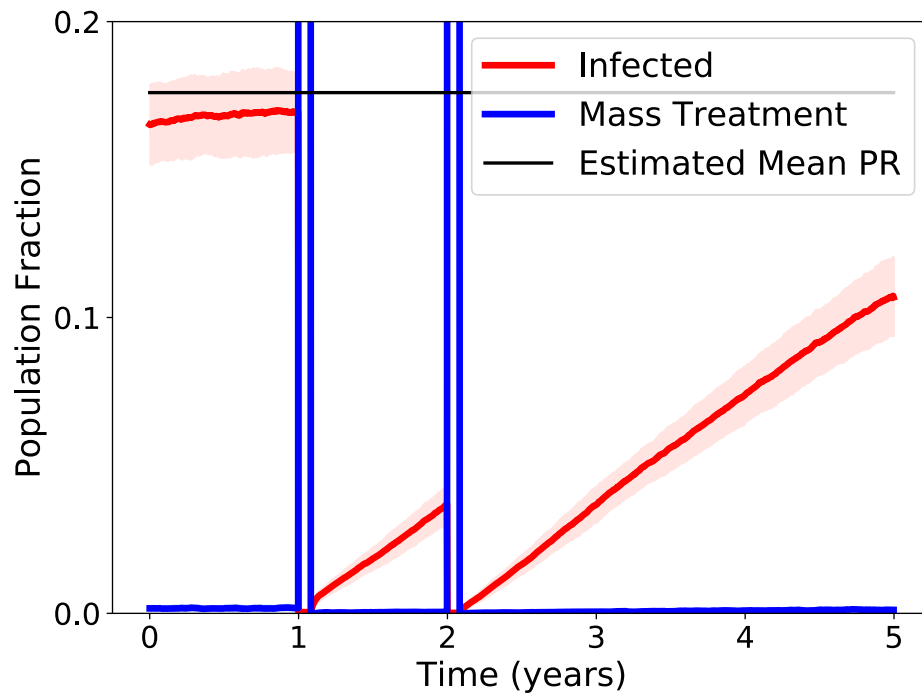
Adding Vaccination



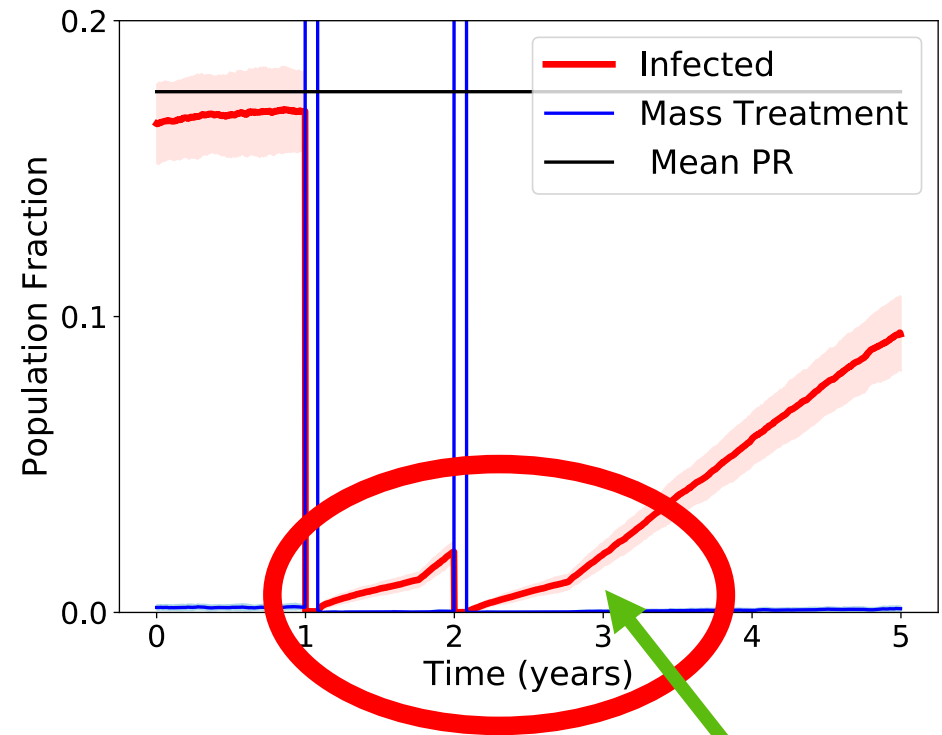
- Improvement – slows down rate of new cases
- Not a permanent fix

Adding Vaccination

Mass Treatment Only



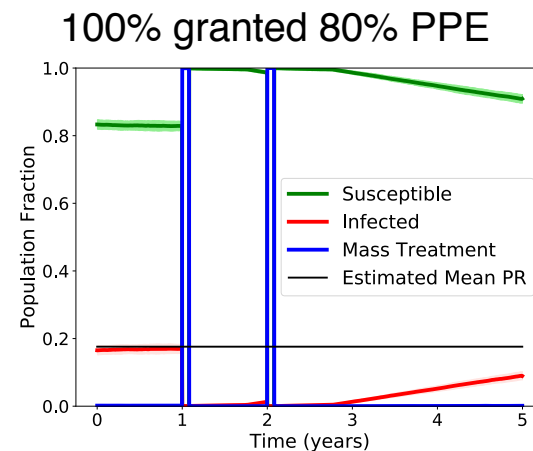
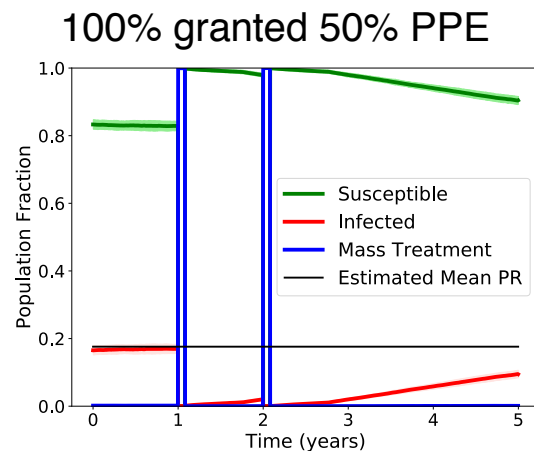
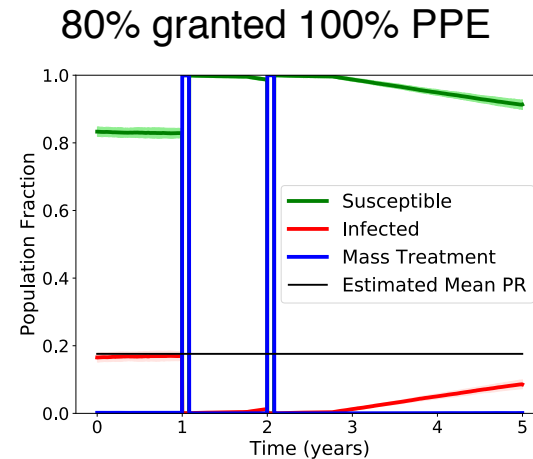
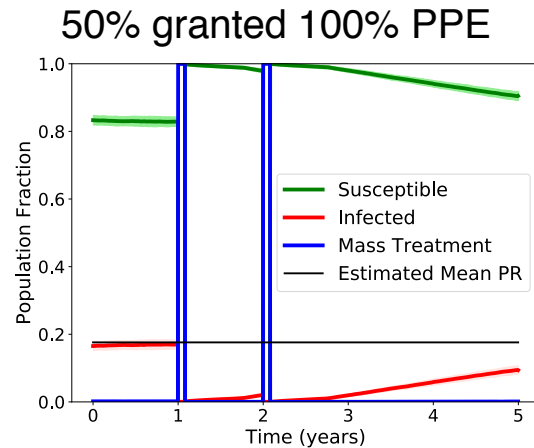
Adding Vaccination



- Improvement – slows down rate of new cases
- Not a permanent fix

Waning
Vaccine

Results Robust to Varying Vaccine Efficacy

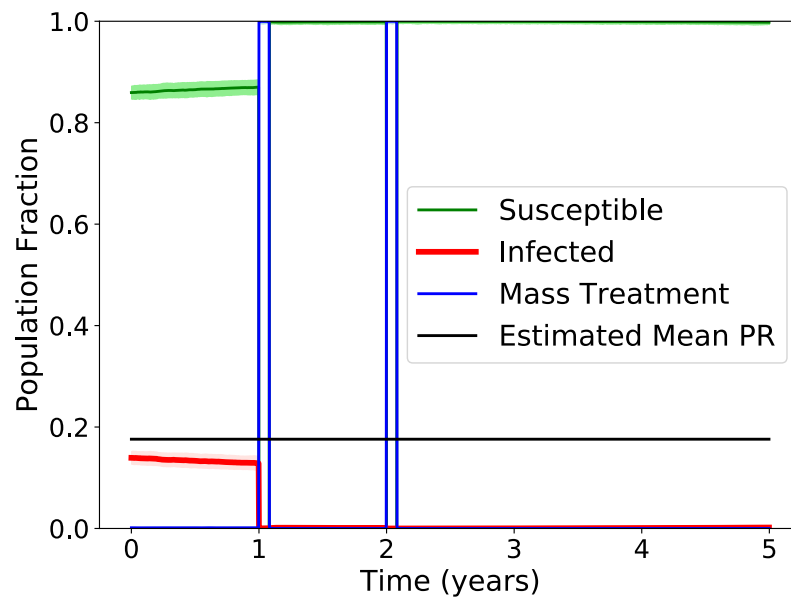


- Temporary protection limits long-term efficacy
- Reintroduction through importation occurs in all cases

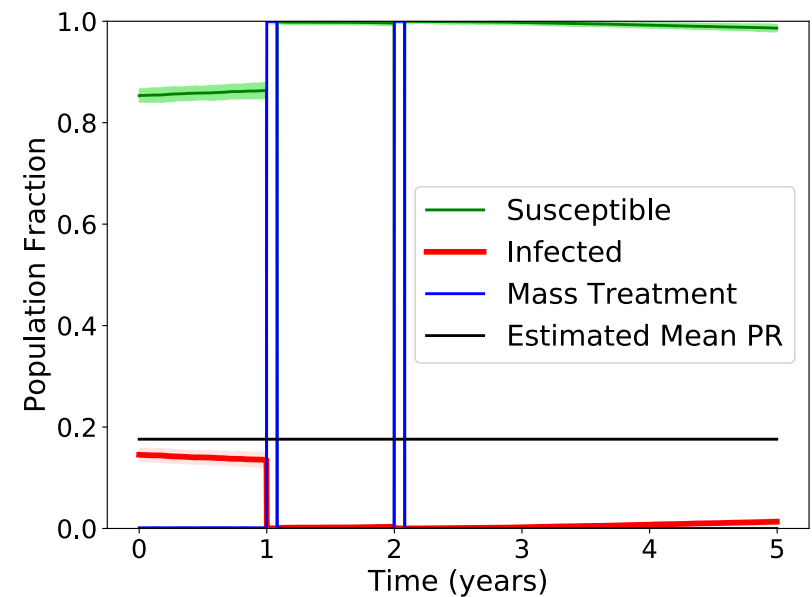
Reducing Imported Cases

- Reduce number of imported infections

100% Reduction



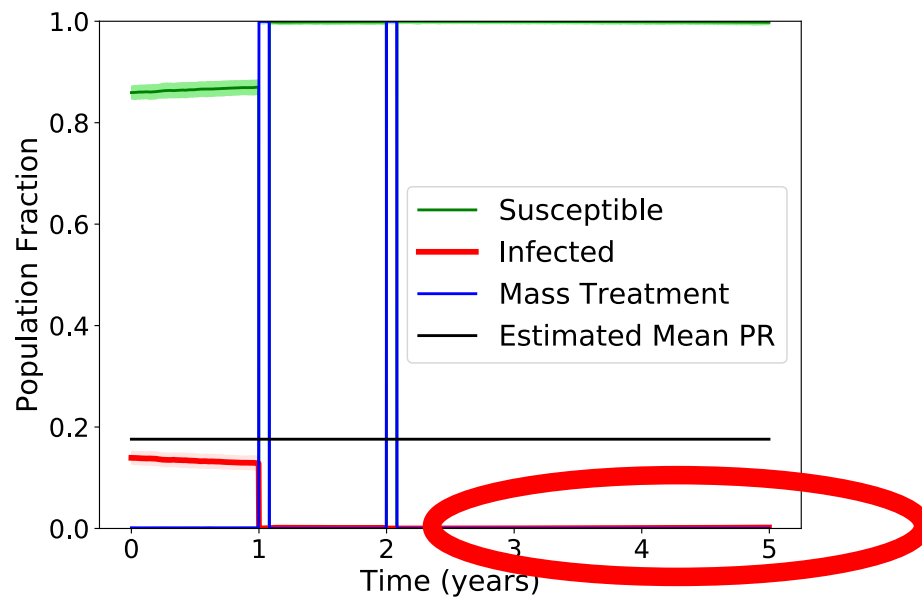
90% Reduction



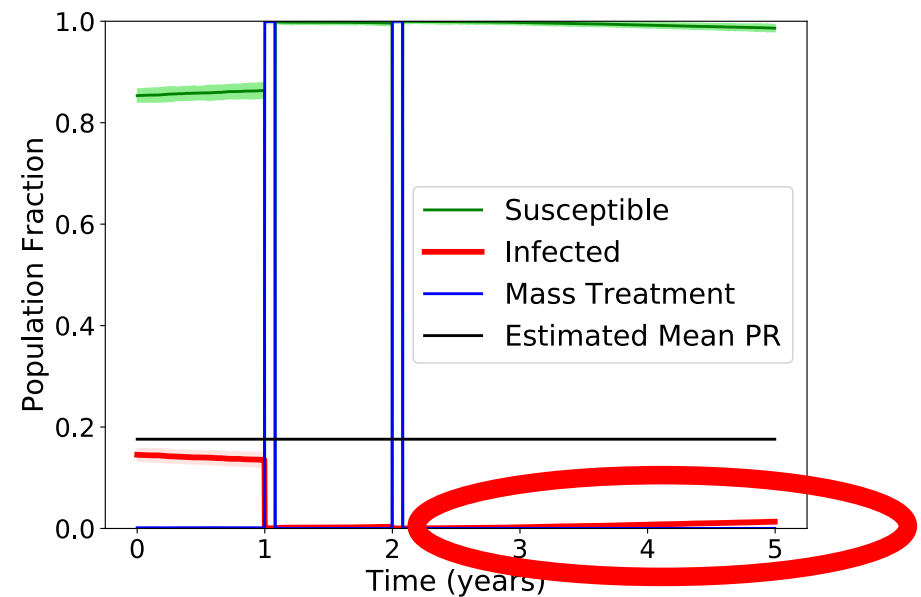
Reducing Imported Cases

- Reduce number of imported infections
- Following vaccination, importations drive return of PR

100% Reduction

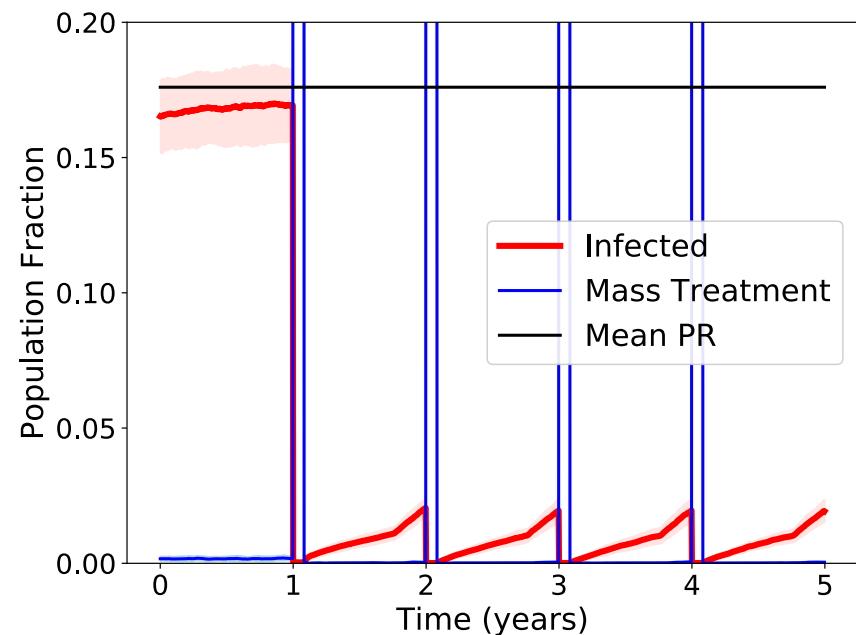
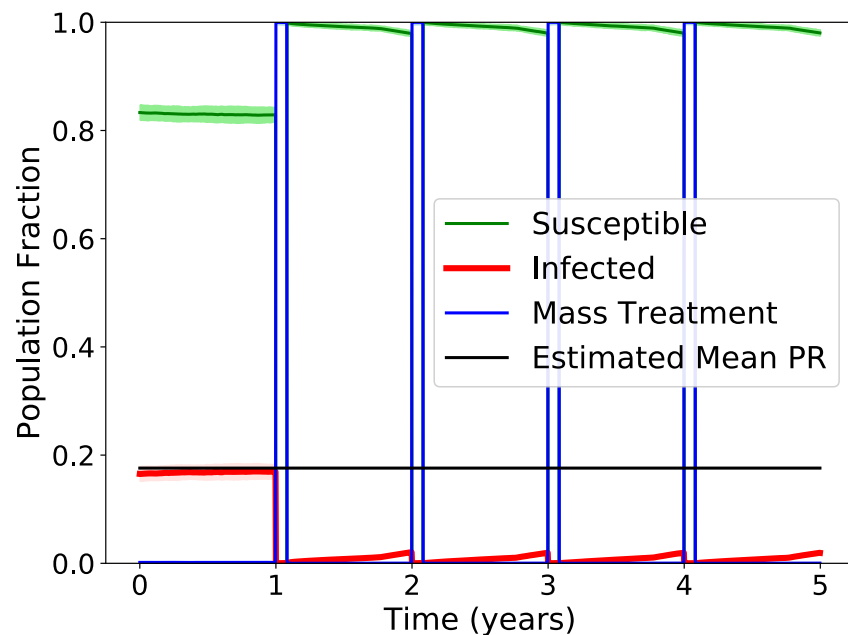


90% Reduction



Annual Distribution of Vaccine

- Vaccine slows rate of new cases in short term
- Possible that periodic re-distribution could contribute to sustaining reduced prevalence



Conclusion

- Is the PfSPZ Vaccine sufficient to interrupt local transmission?
- Our results:
 - Vaccine slows but does not stop transmission over long-term
 - Volume of imported cases appears to be too high
 - Reducing importations, or frequently re-distributing vaccine may hold transmission near zero
- Additional considerations and future work
 - Open to simulating additional proposed scenarios
 - Plan a full sensitivity analysis – assess robustness of conclusions
 - Tools for planning upcoming cluster randomized trials

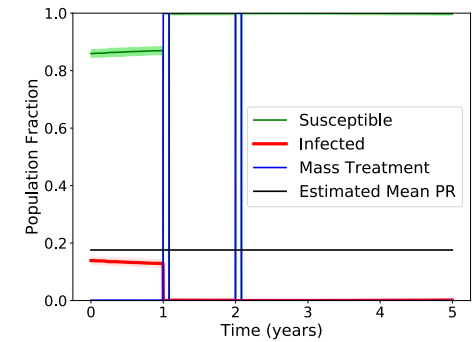
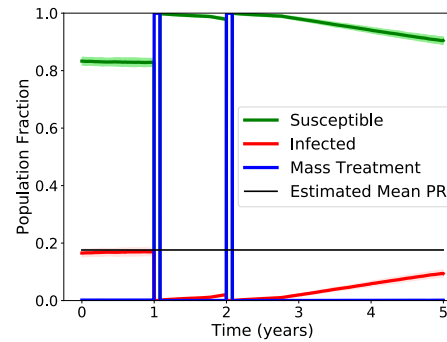
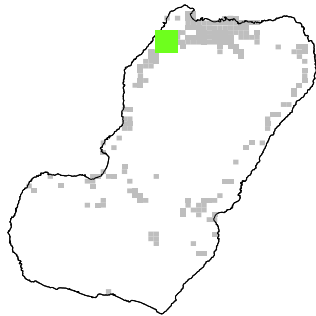


Acknowledgements

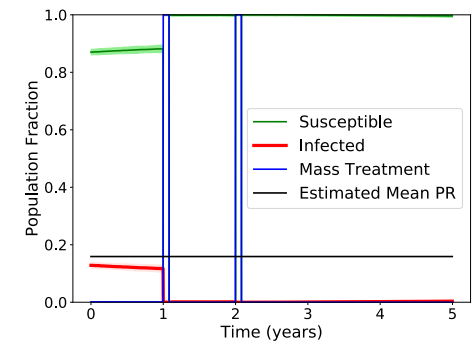
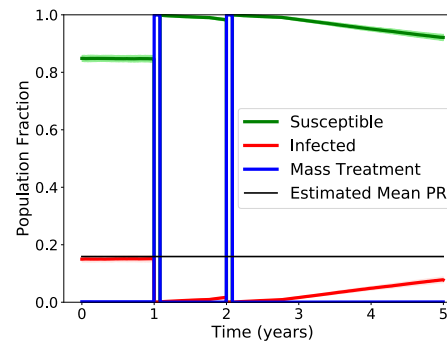
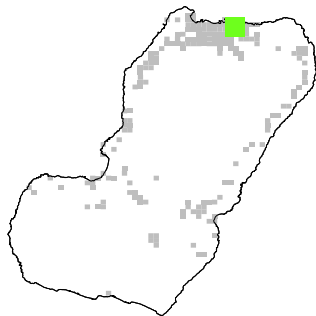
- Support provided by the BMGF
- Sean Wu (designed our software)
- David Smith
- Carlos Guerra
- Dianna Hergott & Guillermo Garcia
- Peter Billingsley & Stephen Hoffman

Results Robust Across Different Areas

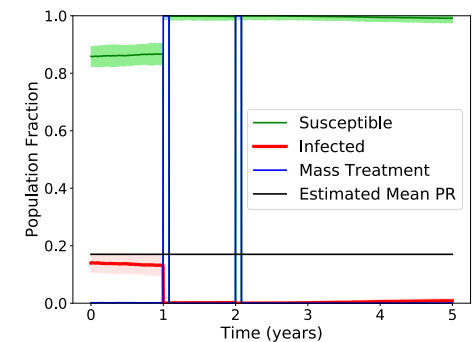
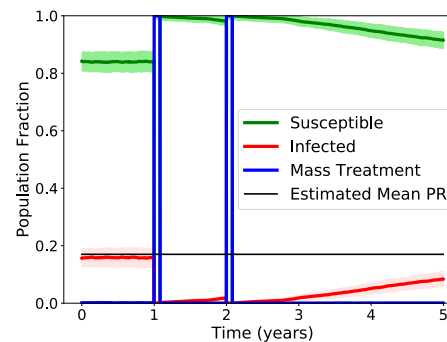
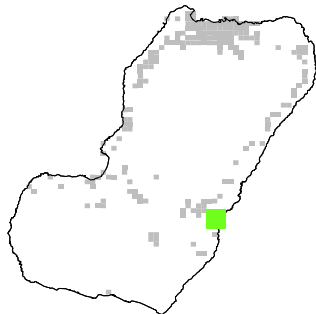
Basupu



Malabo



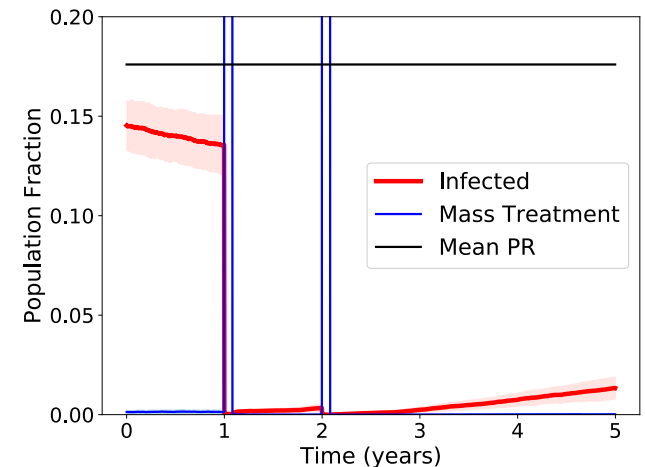
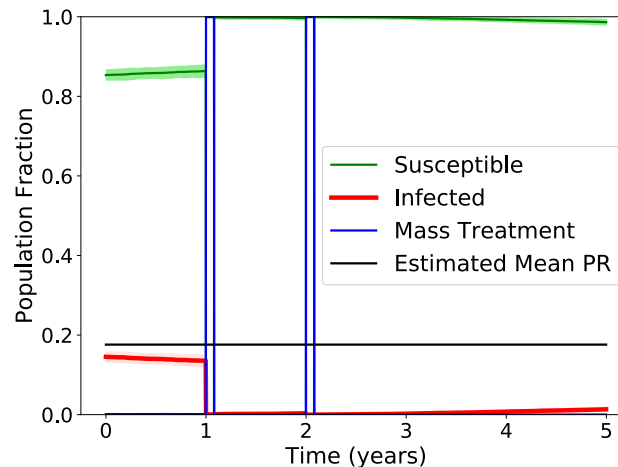
Riaba



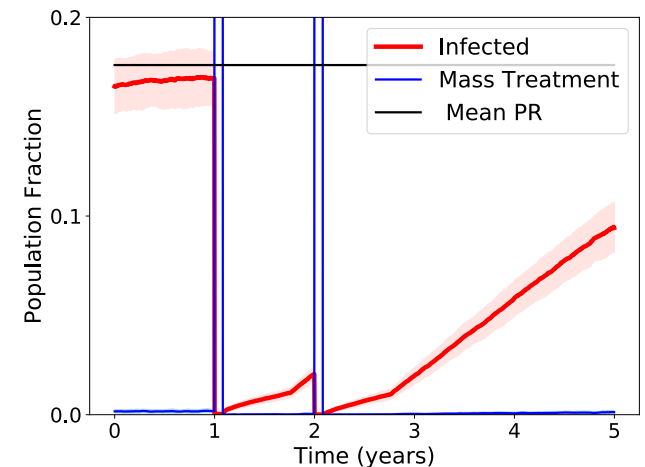
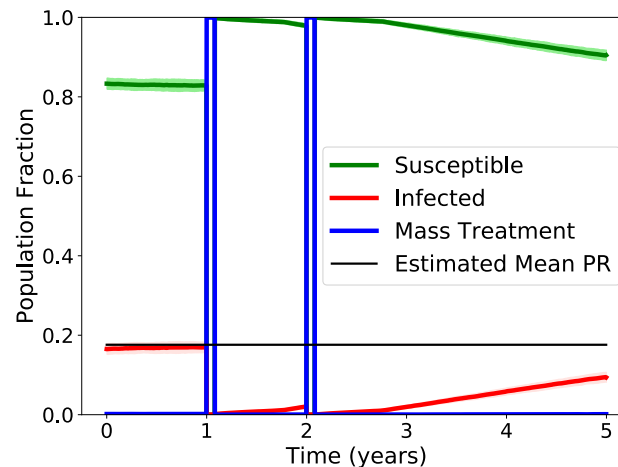
Reduced Importations

- Setting EIR on mainland to mean BI EIR – 90% reduction

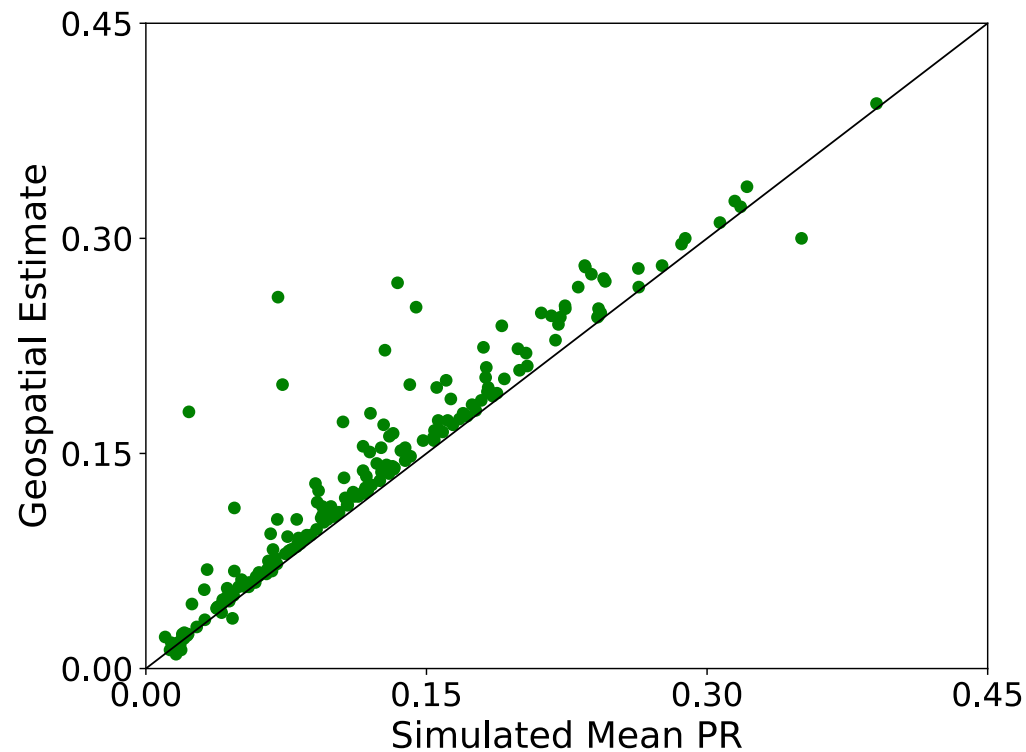
Reduced
Importations



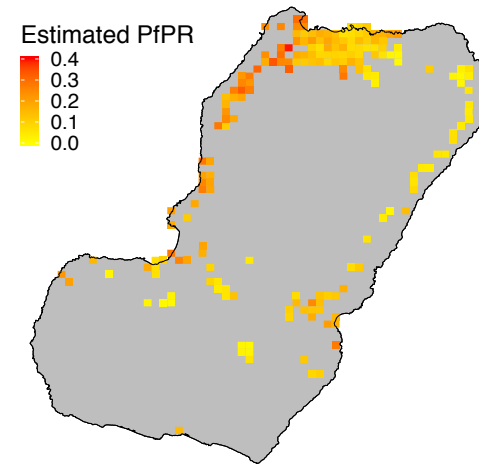
Current
Importations



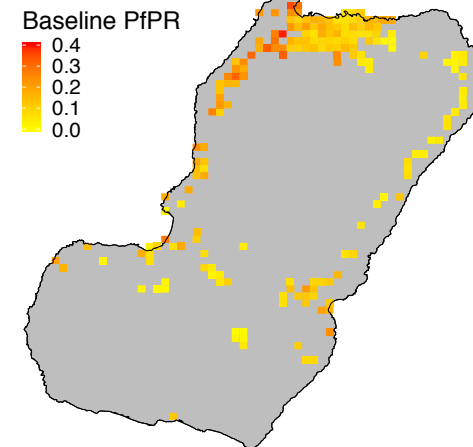
Model Calibration



**Geospatial Estimate
Mean PR**



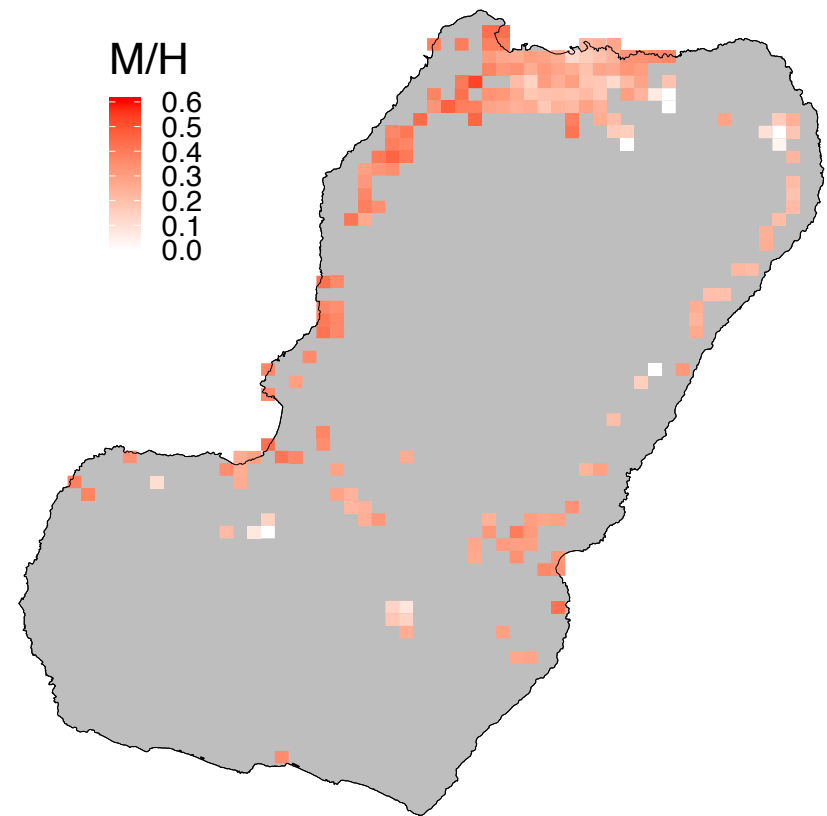
**Calibrated Model
Mean PR**



Mosquito Density

- Mosquitoes/Human, calibrated to PR using Ross-Macdonald
- Accounts for PR attributable to importations

- Lower: East, Malabo, Moka
- Higher: Northwest



Vaccines in the absence of importations

- Set number of infections imported from mainland travel to 0
- Rate of new infections extremely slow without importations

