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Forest cover associated with improved health and nutrition outcomes in Malawi



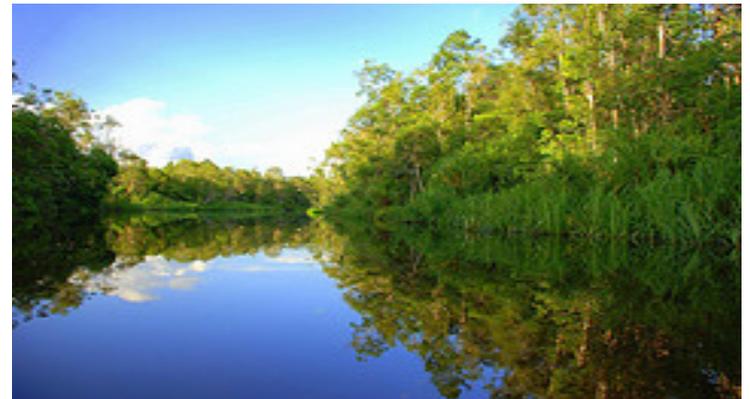
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Background

- Human populations are fundamentally dependent on the environment.
- Dependence on ecosystem services tends to be most direct in the developing world.
- In context of
 - massive biodiversity loss
 - climate change
 - ongoing environmental degradation



...there is an urgent need for evidence-based discussion on ecosystem conservation and human nutrition, health, and development.



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Literature linking integrity of ecosystems and human health & nutrition

- **Nepal:** deforestation as a significant determinant of child nutritional status Kumar and Hotchkiss (1988)
 - **Madagascar:** dependence on consumption of endangered bushmeat to maintain iron stores Golden (2011)
 - **Brazil:** a 4% change in forest cover was associated with a 48% increase in malaria Olson et al. (2010)
- ...but little other empirical research demonstrating relationship between biodiverse environment and human health and nutrition



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Hypotheses

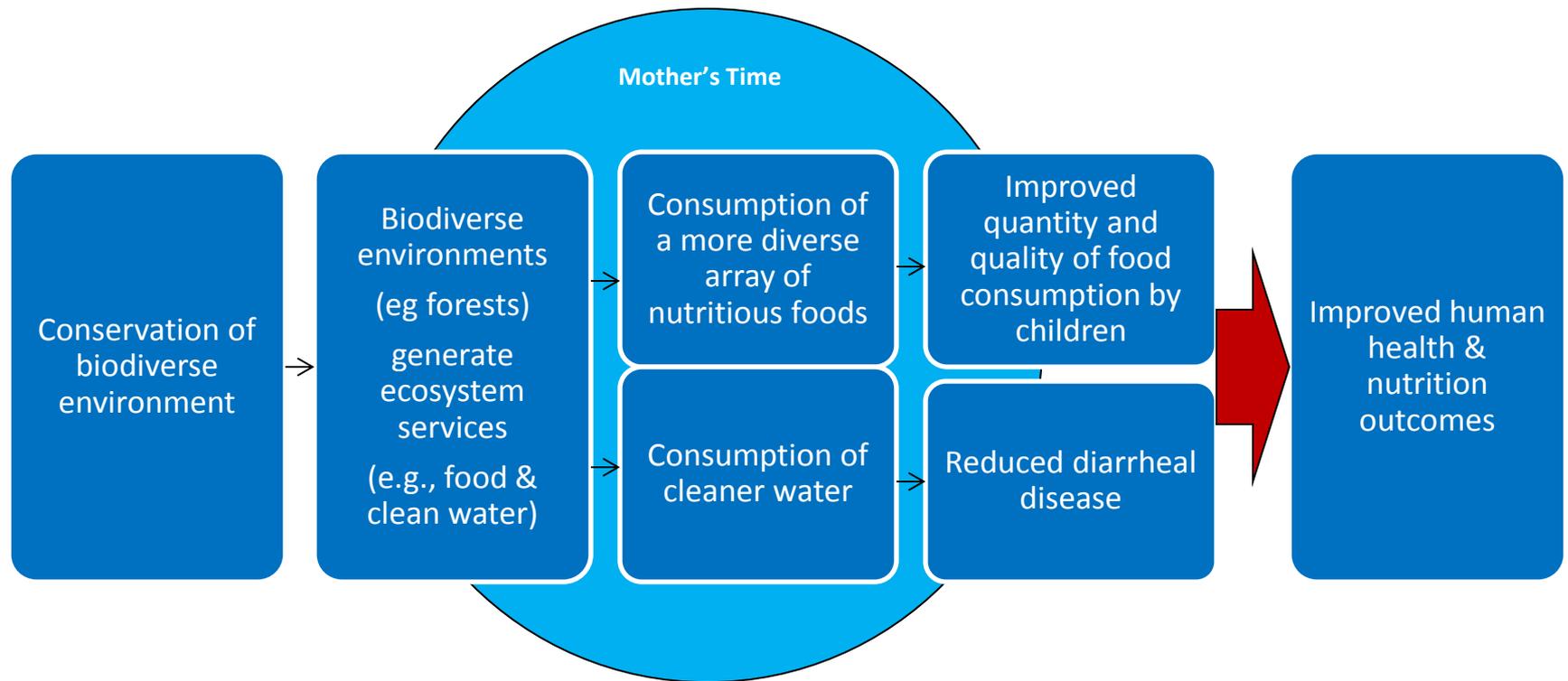
- Degraded environments result in degraded ecosystem services, which open pathways to child undernutrition and consequent poor health, all else being equal.
- Intact environments will have comparatively better capacity to provide essential ecosystem services, which translate into improved human nutrition and health, all else being equal.





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Conceptual Map





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Study Context: Malawi – Population & Health

- Total population: 14.8 million
- Life expectancy: 52
 - Infant mortality rate: 66 deaths per 1,000 live births
 - Under-five mortality rate: 112 deaths per 1,000 live births
- Stunting in children under age 5: 47%
- HIV prevalence: 11%
- Vitamin A deficiency: 60% of preschool aged children



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Study Context: Malawi – Environment

- Total forest cover in Malawi has declined by 17% in the last 20 years (3.9 million hectares to 3.4 million)
- Estimated annual deforestation rates in Malawi vary from 1.6 to 3.4%, depending on the region
- Primary threats to forests include charcoal production, agricultural expansion, and fuel wood collection
- Malawi has 5 protected areas, 4 wildlife reserves, and ~70 forest reserves, covering 1.8 million hectares

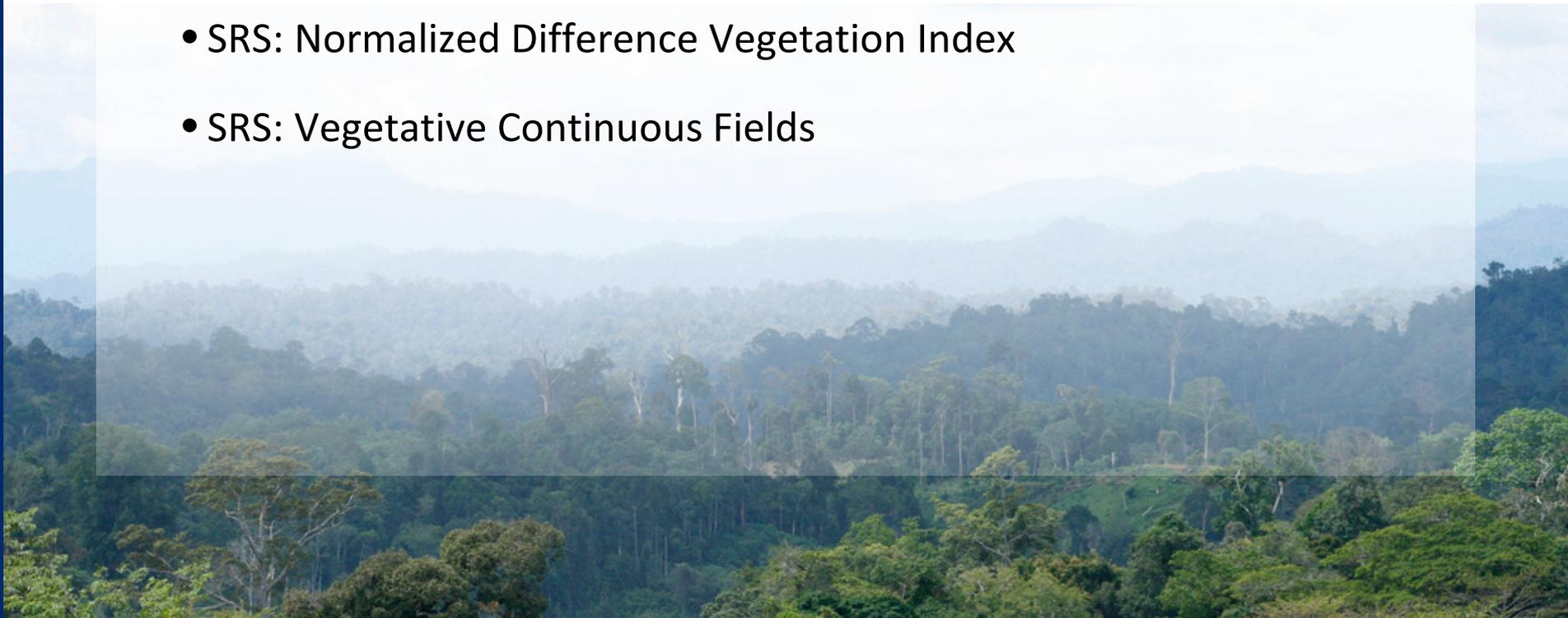


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Data

Three datasets, linked by a common variable (GIS):

- Population and health data from the 2004 & 2010 Malawi DHS
- SRS: Normalized Difference Vegetation Index
- SRS: Vegetative Continuous Fields





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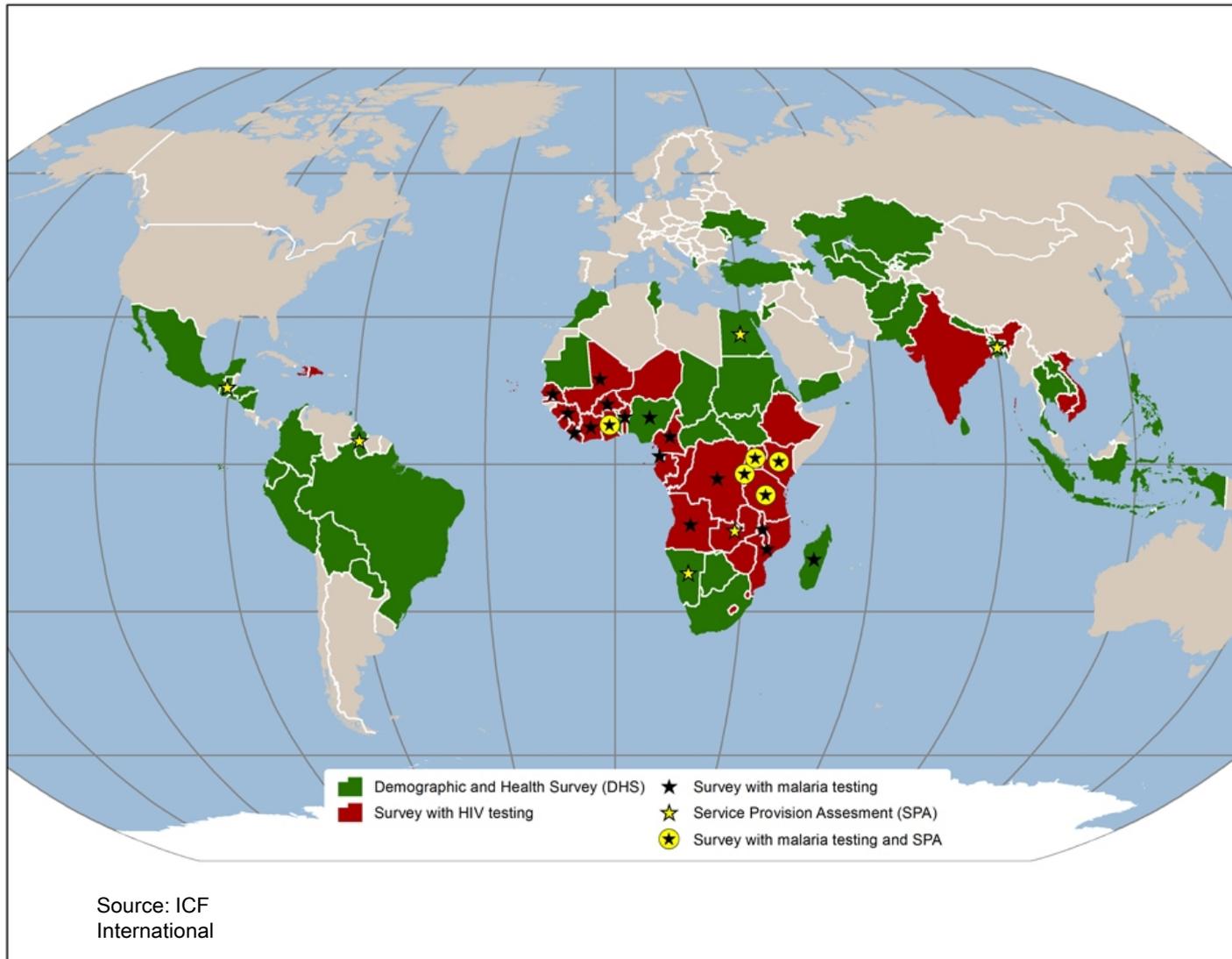


Table 1. Sample details for Demographic and Health Surveys used in the analyses: Malawi 2004 and Malawi 2010.

Survey	Household response rate	Eligible women's response rate	N of interviewed women age 15-49	Unweighted N of children in anthropometric analysis (1)	Unweighted N of children in dietary diversity analysis (2)	Unweighted N for child health status (2)
Malawi 2004	97.8	95.7	11,698	5,654	5,577	6,785
Malawi 2010	98.1	96.9	23,020	3,173	9,166	12,831

(1) Most recent live births to interviewed women occurring <60 months prior to the survey with valid anthropometric measures. Note that in 2010, anthropometry data were collected in only one third of sampled households; thus the disparity between number of women interviewed and number of children in the anthropometric analysis.

(2) Most recent live births to interviewed women occurring <36 months prior to the survey.

(3) Most recent live births to interviewed women occurring <60 months prior to the survey.

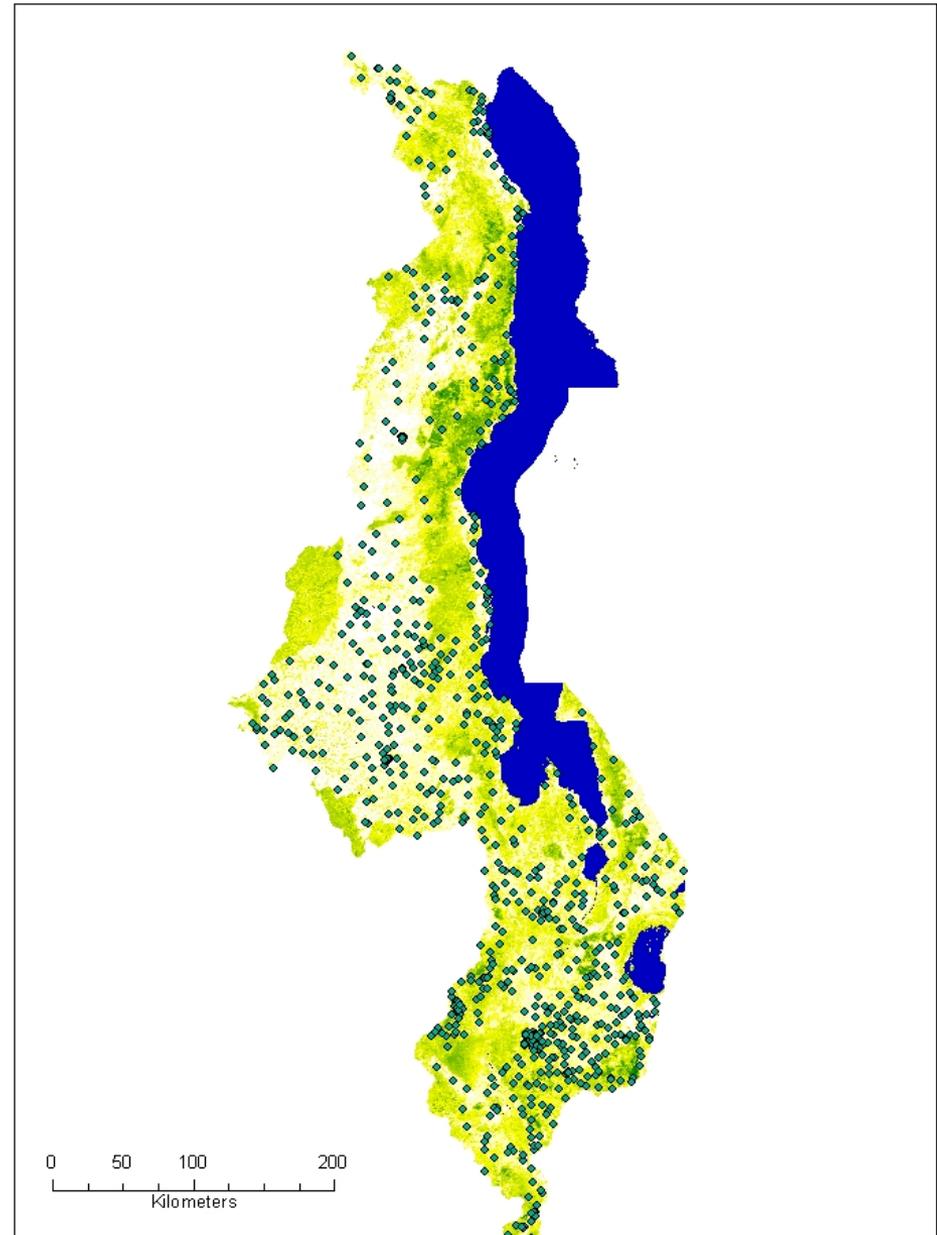


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Satellite Remote Sensing Data

- Vegetation Continuous Fields product:
 - proportional estimates for vegetative cover types: woody vegetation, herbaceous vegetation, and bare ground
 - derived from all seven bands of the MODerate-resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Terra satellite
 - how much of a land cover such as "forest" or "grassland" exists anywhere on a land surface
- NDVI (control): Climate data record derived from AVHRR satellite remote sensing data to produce a variable called the Normalized Difference Vegetation Index

Percent Tree Cover for Malawi





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Methods

- Link satellite remote sensing data on forest cover to population and health data from Malawi via GIS.
- Using multivariate methods, assess the association between child health and nutrition outcomes and proxies for
 - biodiversity (percent forest cover) and
 - biodiversity change (decadal forest cover loss or gain)



Variables included in analysis

- **Dependent Variables**
 - Dietary diversity *Whether the child received foods from 4 or more of the 7 specified food groups*
 - Consumption of vitamin A-rich fruits and vegetables
 - Diarrheal disease
 - Stunting
- **Independent Variables**
 - Percent forest cover (cluster; available for 2004 & 2010)
 - Change in forest cover over past 10 years (2010 only)
- **Control Variables**
 - Child's age, water source, toilet facility, mother's education, residence, wealth quintile, NDVI, time since migration



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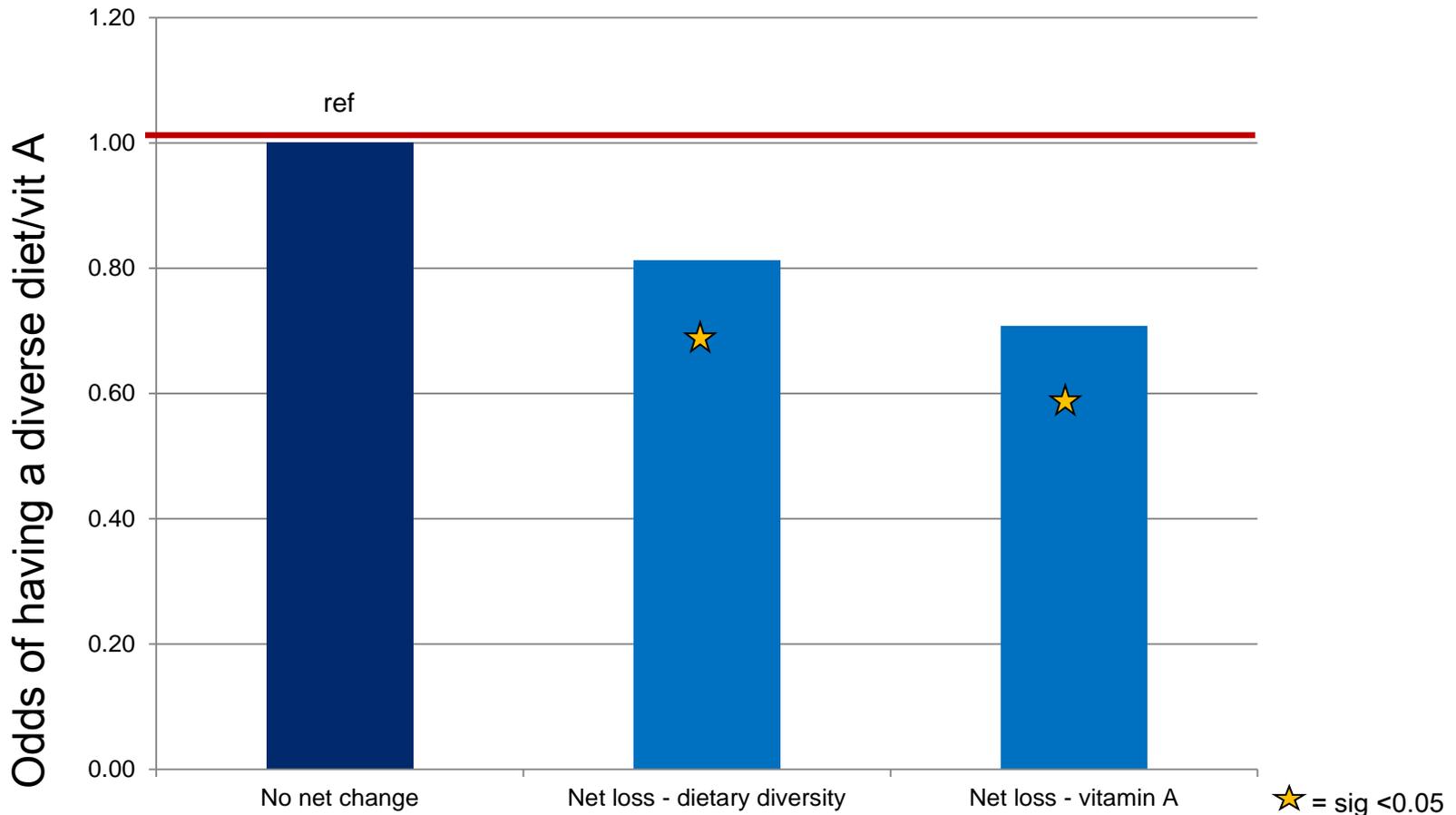
Assumptions

- Forest cover correlates positively with biodiversity
- Deforestation correlates negatively with biodiversity





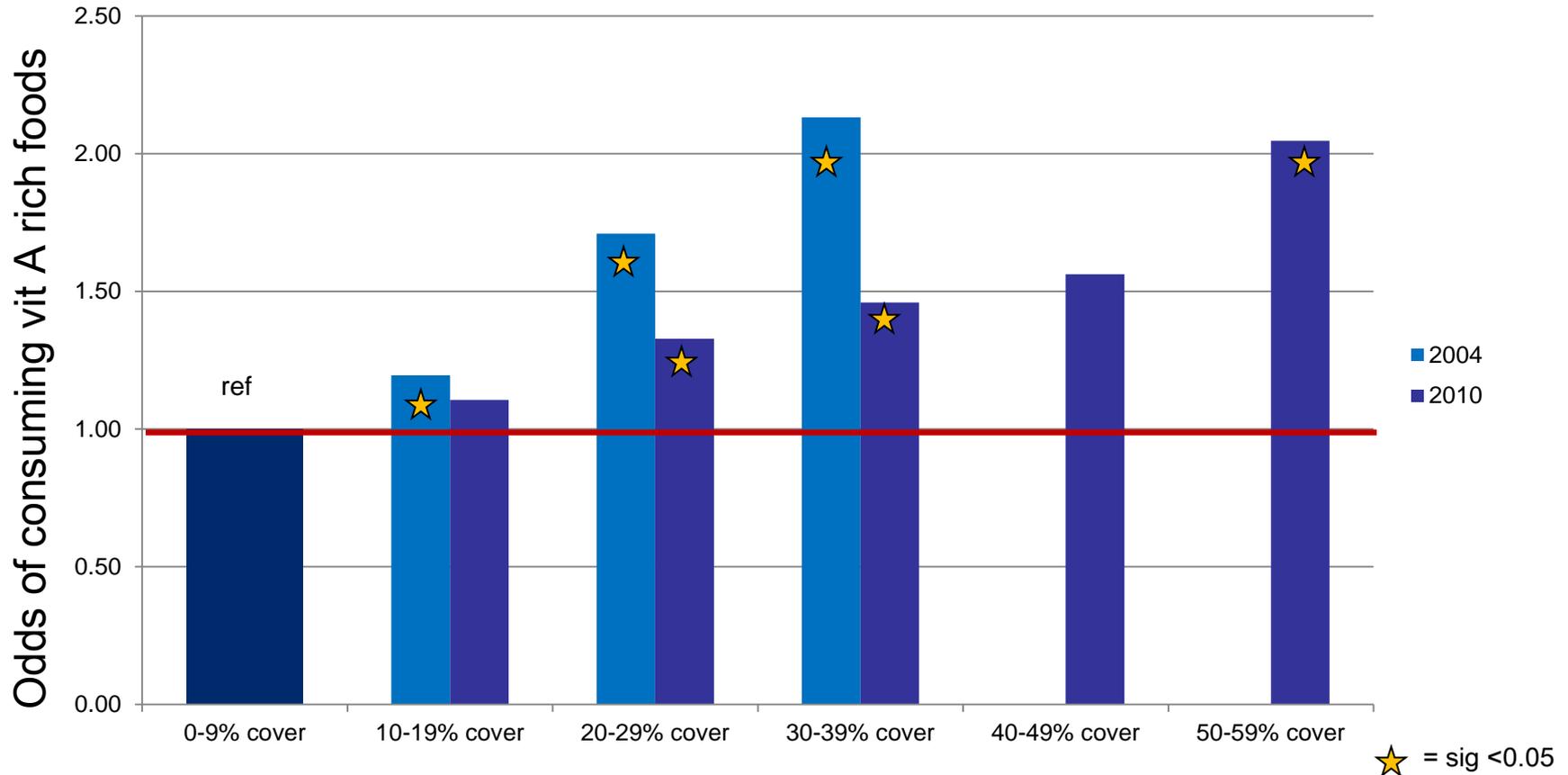
Net loss of forest cover reduces odds that a child will have a diverse diet & consume vitamin A rich foods:





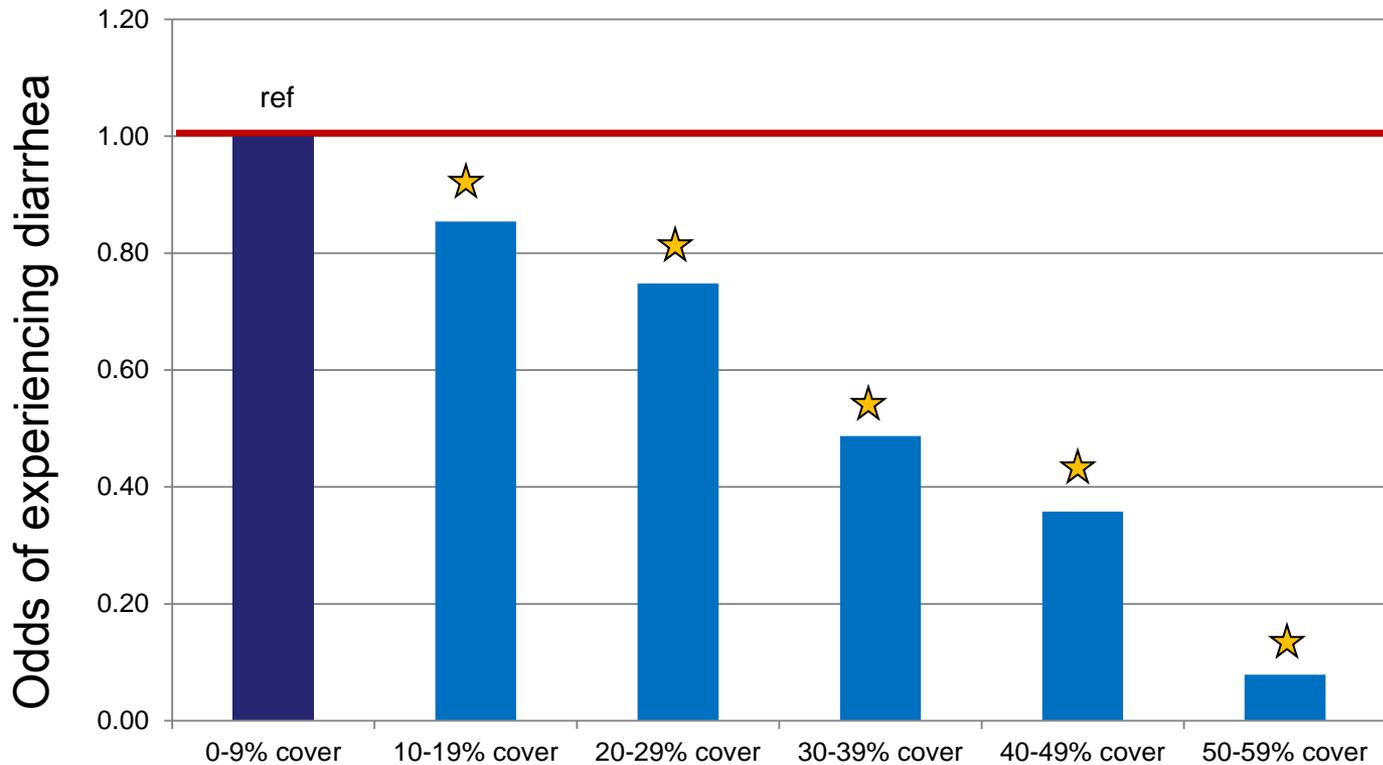
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Children in communities with greater forest cover have increased consumption of vitamin A-rich foods:





As forest cover increases, children have reduced odds of experiencing diarrhea:



★ = sig <0.05



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Limitations

- Displacement of DHS geo-referenced data points
- Environmental datasets don't reflect management status
- Observational, cross-sectional study.





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Discussion & Conclusions

- Results are broadly consistent with our hypothesis, while highlighting areas requiring further investigation.
- Relationship of forest cover to the selected nutrition and health outcomes is sufficiently consistent & strong to suggest a protective effect of forest cover in Malawi
 - Do the relationships generally hold across different contexts?
 - What are the pathways by which these associations are expressed?
- Suggestion that certain types of reforestation may have negative impacts needs further investigation



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Thank you!

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