Impact of Community-Based Forest Management on Bird Species Diversity: Evidence from Nepal's CFUG Program

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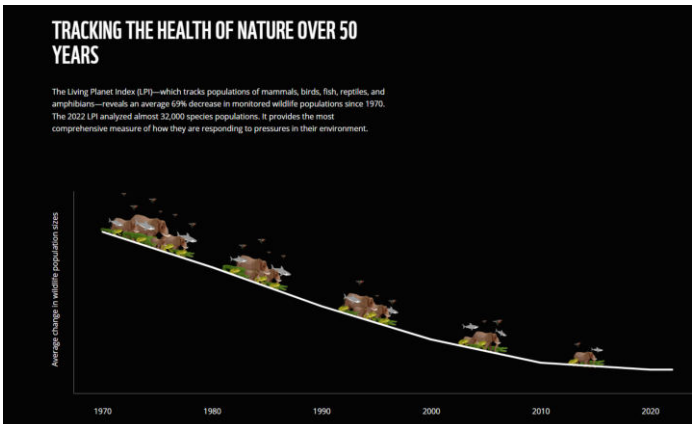
Outline

Global Biodiversity Loss



WWF Living Planet Report 2022

Key Points:

- Global biodiversity has declined by 69%.
- Increasing traditional conservation and restoration efforts is key.

Global Biodiversity Loss in Terrestrial Ecosystem

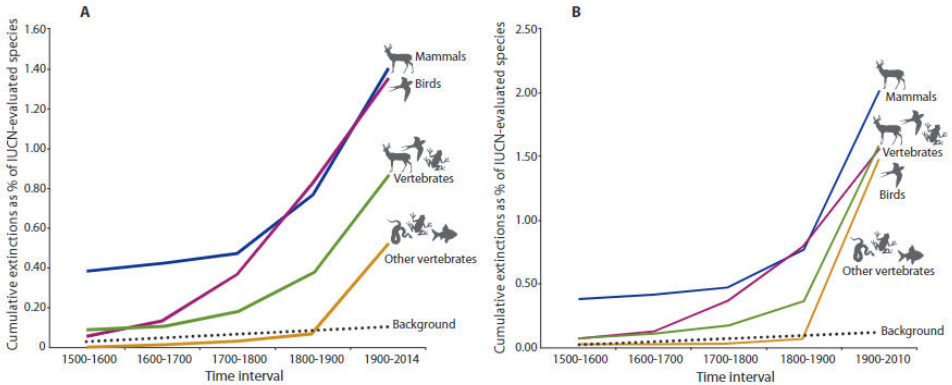


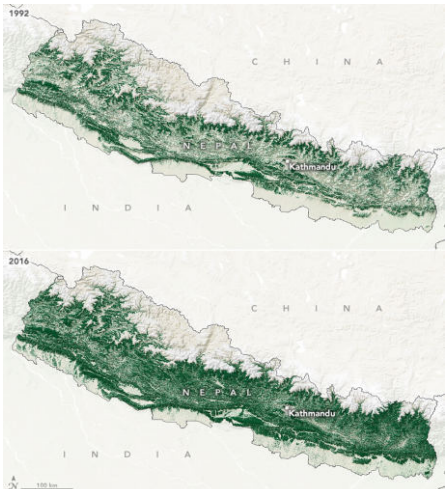
Fig. 1. Cumulative vertebrate species recorded as extinct or extinct in the wild by the IUCN (2012). Graphs show the percentage of the number of species evaluated among mammals (5513; 100% of those described), birds (10,425; 100%), reptiles (4414; 44%), amphibians (6414; 88%), fishes (12,457; 38%), and all vertebrates combined (39,223; 59%). Dashed black curve represents the number of extinctions expected under a constant standard background rate of 2 E/MSY. (**A**) Highly conservative estimate. (**B**) Conservative estimate.

Ceballos et al., 2015

Motivation

- Large literature on decentralisation of resource management (Adam & Eltayeb, 2016; Baland et al., 2018; Bluffstone et al., 2015; Somanathan et al., 2009).
- Community-based resource management like community forests has impacts on biodiversity (Tilman et al., 2014).
- Impacts of communities on forest are a mixed bag (Datta et al., 2012; Desbureaux, 2016)

Canopy Image of Nepal: 1992 & 2016



From:

- NASA Earth Observatory: How Nepal regenerated its forests

Literature

- Evaluation of Community-based forest management impacts:
  - Poverty outcomes like consumption, firewood collection, (Baland et al., 2010, 2018; Oldekop et al., 2018, 2019).
  - Forest Cover and Biomass (Libois et al., 2022; Rasolofoson et al., 2017; Santika et al., 2019).

- Increase in forest cover and biomass does not necessarily mean increase in biodiversity functioning (Chazdon, 2008). Monoculture and Large Mammals.

Other Literature

- Evaluation of biodiversity functioning using eBird data:
  - Infrastructure-Biodiversity Tradeoff (Madhok, 2023)

Why Birds?

- Birds are a strong indicator of biodiversity functioning (Fraixedas et al., 2020).
- Larger number of species indicate richer ecosystem (Cazalis et al., 2020)
- Bird data available on eBird.

Research Questions

Did bird species richness increase with spread of community forestry in Nepal?

Does VDCs near to national parks differ from villages far away?

Which birds benefited out of the program?

Community Forest User Groups

- Formally in early 1990s with amendment to National Forest Act, 1993.
- 50% of forests transferred to 19,000 forest user groups across Nepal.
- **Primary use**: Firewood and Fodder collection, Grazing, Water resource, Timber, Non-timber forest products.
- **Constraint**: No agriculture or open grazing within forest boundary

CFUG census

- CFUG census record information on
  - CFUG name
  - VDC it is housed in
  - Date of Operation
  - Forest Area (in ha.) under CFUG
  - Number of households and members.

- Most of the new CFUGs were created right after the onset. Few were created after 2000s.

Treatment Variable

Percentage of VDC area under CFUGs in a Year-Month.

eBird

- Information on:
  - species observed
  - User ID and geolocations
  - date and time of trip
  - trip duration (in minutes)
  - protocol type
  - number of observers in a trip

Reduce False Detections

Your Black-naped Oriole observation in eBird Inbox ×

Anurag Mishra via eBird <ebird-review@ebird.org> Tue, Aug 20, 5:45 PM (11 days ago)
to me, anuragmishra1009

Dear Agnij Sur,

Thank you for being a part of eBird. To help make sure that eBird can be used for scientific research and conservation, volunteers like me follow up on unusual observations as a part of the eBird data quality process.

I am writing about the following observation:

Species: Black-naped Oriole
Count: X
Observation Date: Jun 13, 2014
Location: Kuldiha Wildlife Sanctuary, Baleswar, Odisha, IN
https://ebird.org/checklist/S64461743

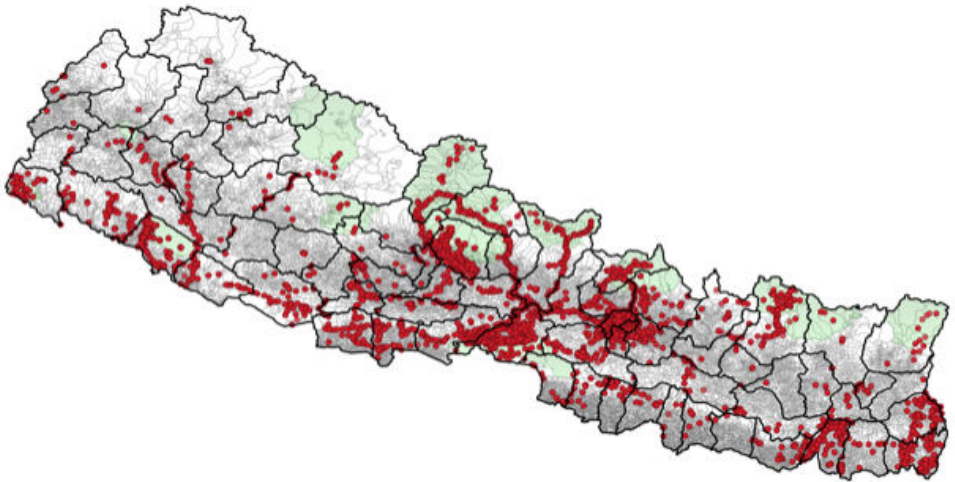
The species you reported was flagged for review and is unusual for this date and/or location. Could you please edit your checklist to add field notes or a description of the bird in question and other information about how you identified this species? Essential things to cover include size, shape, color pattern, behavior, vocalizations (if heard), and habitat. Notes on how similar species were eliminated are especially important.

Photos and audio recordings are the best possible supporting information, so if you do have those please do upload them to your checklist. Once you add media or additional details, I will be prompted to rereview the observation. Minimum standards of documentation are required for observations to be used publicly, although they still will appear in your personal lists.

Constraints ensuring Data Quality (Johnston et al., 2021)

- Accurate variation in species detection (Complete).
- A non-detection is then a non-detection (Protocol).
- Normalise observer effort (Duration, Group Size)
- Trips that fall within the VDC boundaries.

eBird Trips across Nepal VDCs, 1980-2022



Outcome Measure

- Mean Species Richness
- Average number of species observed by user in each trip in a VDC-year-month.

- Repeated sampling design; controls observer's unknown learning function.

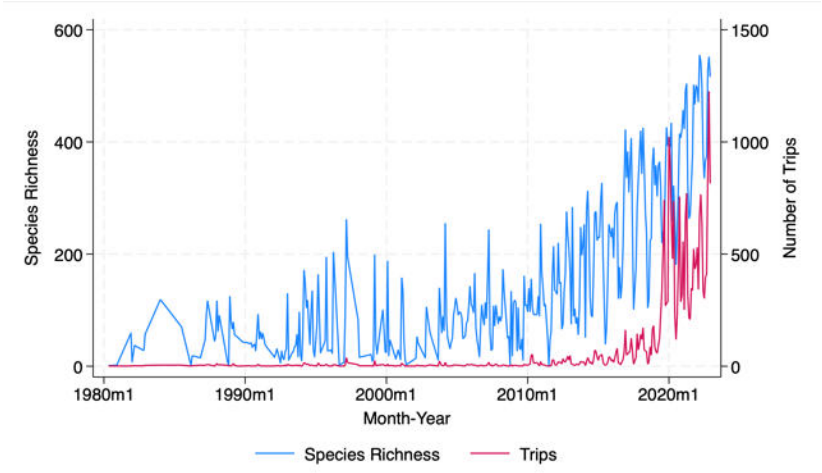
Descriptive Statistics: eBird trips

Variable	Mean	SD	Min	Max	N
By VDC					
Num. Users	6.84	19.03	1	293	912
Num. Trips	28.89	212.08	1	5436	912
By User					
Num. VDCs	6.03	15.19	1	294	1036
Num. Districts	3.13	3.92	1	40	1036
Num. Year-Months	3.45	9.11	1	198	1037
By User-VDC-Month					
Species Richness	23.74	18.92	1	186	9,001
Number of Trips	2.32	10.15	1	501	9,001
Duration (mins)	109.61	80.56	1	300	9,001

Descriptive Statistics: CFUGs

Variable	Mean	SD	Min	Max	N
By VDC					
Cumulative Area under CFUG	9.00	8.70	0	71.33	2,766
Num. of HH	148.12	177.62	11	2875	2,792
Mem. in Comm.	11.78	2.00	5	33	2,677
Female Mem.	3.89	1.69	1	23	2,617

Mean Species Richness and Number of Trips



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Empirical Model

$$SR_{ivdym} = \alpha + \beta_1 (CFshare)_{vdym} + \beta_2 (CFshare)^2_{vdym} + \phi_{iy} + \gamma_v + \theta_{dm} + \mathbf{X_{ivdym}\Theta} + \epsilon_{ivdym} \quad (1)$$

- ϕ_{iy} is User-Year FE, γ_v is VDC FE, and θ_{dm} is District-Month FE.
- $\mathbf{X}_{ivdym}$: average observer effort + proportion of trip protocol

Treatment Endogeneity

- CFUGs were formed based on administrative connections or proximity to district headquarters.
  - Downward bias — if CFUGs were formed to manage faster degrading forests.
  - Upward Bias — if CFUGs were formed for forests which were already improving.

Identification through DAG

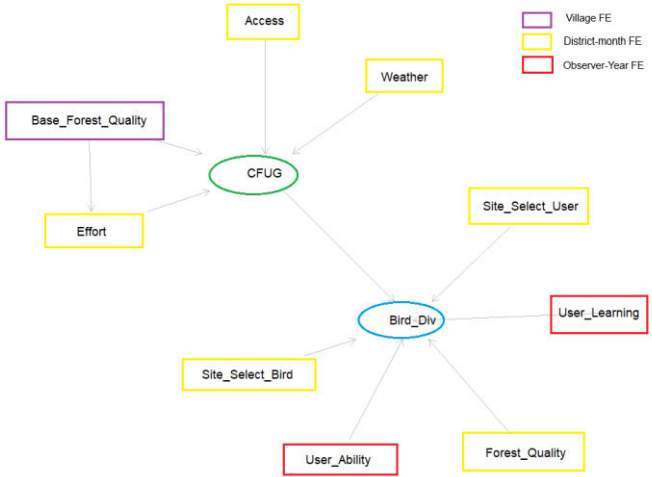
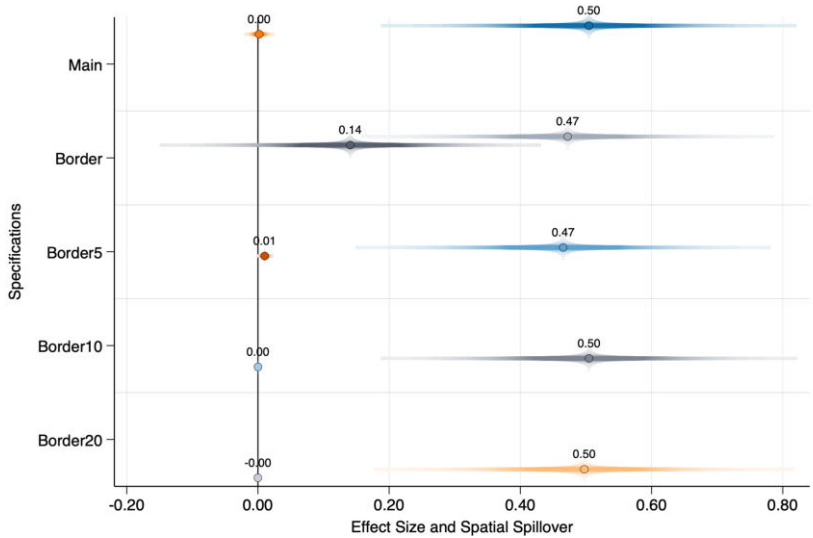


Figure: Confounders DAG

Impact of Community-based Forest Management on Bird Species Diversity, 1991-2022



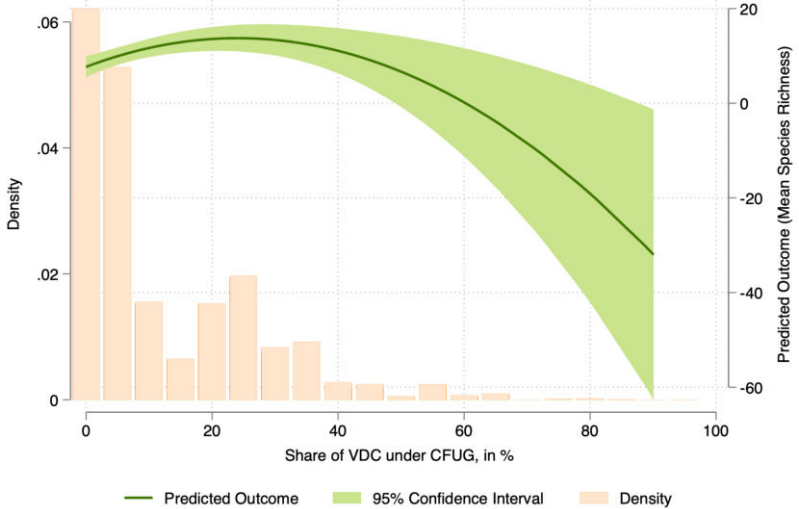


Figure: Evolution of Bird Diversity with CFUG program

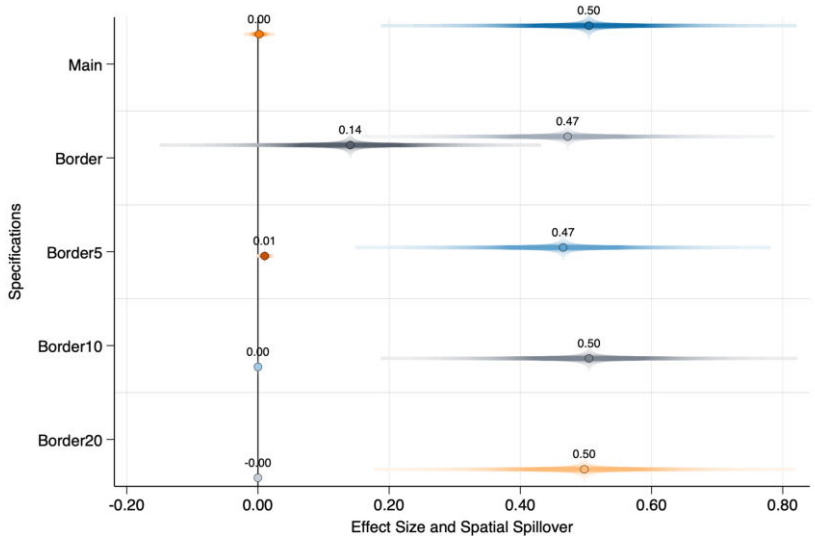
SUTVA: Contiguity Matrix

- $\mathbf{W_v}$ is a $V \times V$ symmetric matrix. w_{ij} if VDC i shares border with VDC j, else it takes the value zero.
  - Binary Contiguity: $w_{ij} = w_{ji} = 1$
  - Inverse-Distance Weighted: $w_{ij} = \frac{1}{d_{ij}}$, d_{ij}

Test for Spatial Spillover

$$SLCF_{vdym} = (I_T \otimes W_v).[CFshare_{vdym}] \quad (2)$$

Estimates of Spatial Spillover



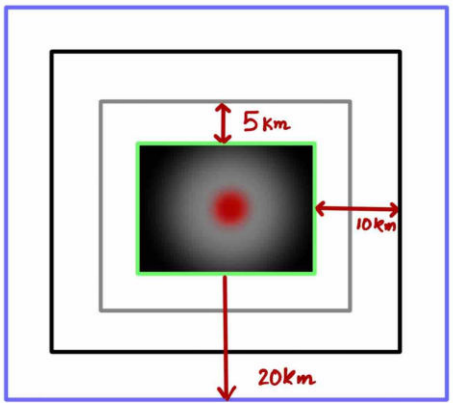
Sensitivity Estimates

	1	2	3	4	5
	No 2020	Till 2017	Shannon's	Simpson's	Trips
CF Area (%)	0.462***	0.445***	0.012***	0.002	0.568***
	(0.121)	(0.167)	(0.008)	(0.002)	(0.127)
Fixed Effects	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Observations	7919	1881	8763	8763	8763
R-squared	0.759	0.843	0.705	0.558	0.789

Robust standard errors in parentheses. All specifications controls for observer effort, protocol type, user-by-year FE, village FE, district-by-month FE. Outcome in column 1 and 2 is Mean Species Richness. Column 3 uses Shannon's Index and column 4 uses Simpson's Index as outcomes. Column 5 is weighted by number of trips. Controls $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Alternative Indices

Buffer Zones



Proximity to National Parks

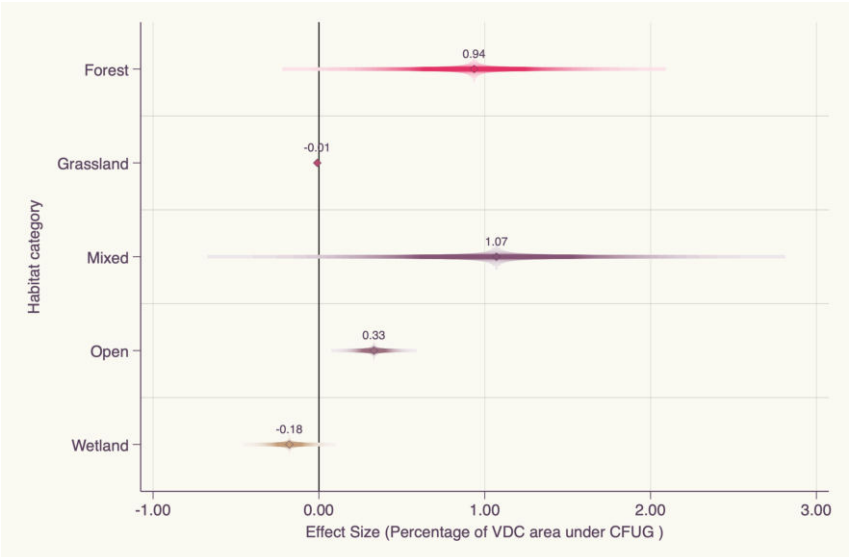
	Mean Species Richness				
Buffer (kms)	0	5	10	20	Sal
CF share (%)	0.504***	0.559***	0.673***	0.706***	0.426***
	(0.123)	(0.128)	(0.207)	(0.249)	(0.123)
CF Share × Buffer	-0.898	-0.199	-0.171	-0.180	0.305
	(1.236)	(0.202)	(0.177)	(0.187)	(0.187)
Controls	✓	✓	✓	✓	✓
Observations	8763	8763	8763	8763	8763
R^2	0.756	0.756	0.756	0.756	0.756

Robust standard errors in parantheses. All specification controls for observer's average trip duration, average group size, and protocol proportion. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Only Bird

Spiny Babbler (Endemic to Nepal) © Manshanta Ghimire

Estimates by habitat type



IUCN status

- IUCN categorises bird species
  - Least concern
  - Near Threatened
  - Vulnerable
  - Endangered
  - Critically Endangered
- Counts of unique bird species falling in either group across trips in a VDC-year-month.
- 98% in the first group, 2% in the second group.

Estimates by IUCN threat status

	Least Concern		Endangered	
	Level	Poisson	Level	Poisson
CF Area (%)	0.797	0.020*	0.004	0.009
	(0.524)	(0.011)	(0.004)	(0.106)
Fixed Effects	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Observations	8761	8763	8763	518
R squared	(0.289)		(0.257)	

Robust standard errors in parentheses. All specifications controls for observer effort, protocol type, user-by-year FE, village FE, district-by-month FE. Least Concern includes species from Least Concern and Near Threatened categories. Endangered considers species from Vulnerable, Endangered, and Criticially Endangered groups. Column Level is the OLS estimate and column Poisson is the PPML estimate. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Mechanism

Bluffstone et al. (2020) - Public goods experiment in Nepal.

People in formal CFUG are more inclined to collective action and believe others will follow suit. Collective action towards forest regeneration were associated positively with their CF status compared to other informal groups.

What is happening now?

- Forest Regulations Act 2021 - Renewal every 5-10 years
- National Natural Resources and Fiscal Commission: New tax on community forest and revenue sharing with Central Government
- Human Wildlife Conflict without proper compensatory mechanism (Bhushal, Bernabas, & Lal, 2024)
- Elite capture (Dahal & Chapagain, 2017; Persha & Andersson, 2014)

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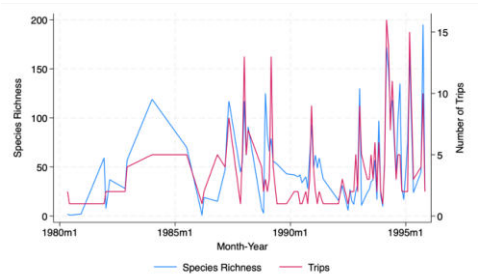

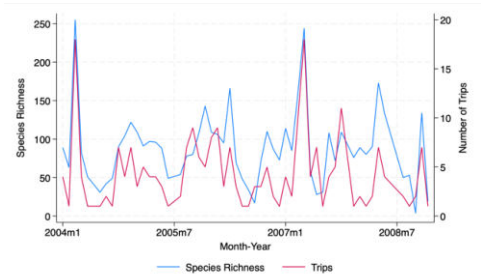

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- Alternative index — p_{sj} = proportion of birds of species s in a trip j. Outcomes are averaged across each observer's total trips in a VDC-year-month
  - Shannon's Index: $SH_j = -\sum_{s=1}^{S} p_{sj} \ln(p_{sj})$
  - Simpson's index: $SI_j = 1 - \sum_{s=1}^{S} p_{sj}^2$

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$$\#User_{vdym} = \alpha + \beta_1(CFshare)_{vdym} + \beta_2(CFshare^2)_{vdym} + \beta_3 SLCF_{vdym} + \gamma_{vy} + \theta_{dm} + \mathbf{X_{vdym}\Theta} + \epsilon_{vdym} \tag{3}$$

	Mean Species Richness		
	(5)	(10)	(20)
CF Share (ha.)	-0.201	-0.164	-0.183
	(0.200)	(0.198)	(0.194)
Controls	✓	✓	✓
Observations	6896	6896	6896
R^2	0.732	0.732	0.732

Robust standard errors in parentheses. All specification estimate Equation 3 with outcome mean species richness and different fixed effects form. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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