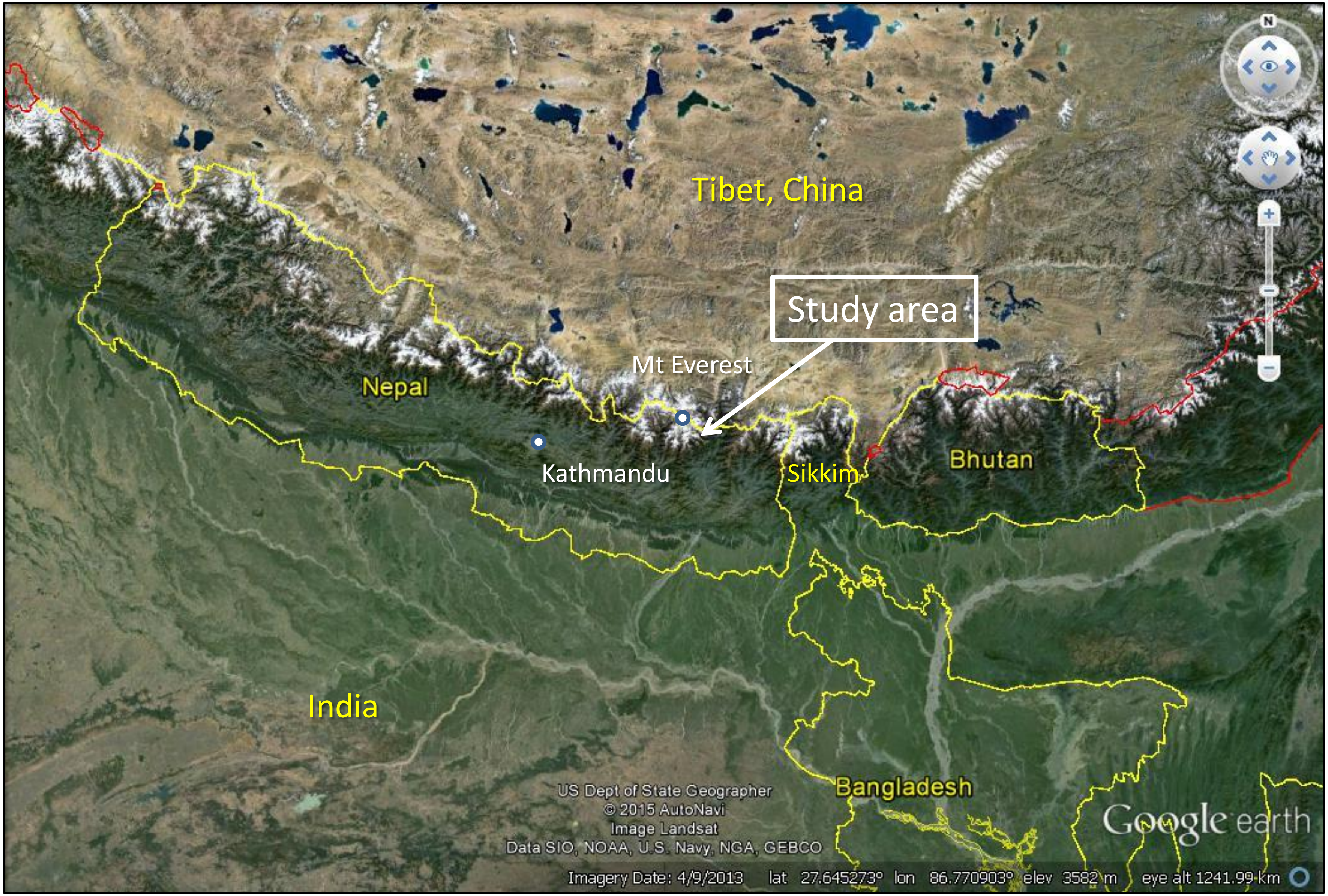
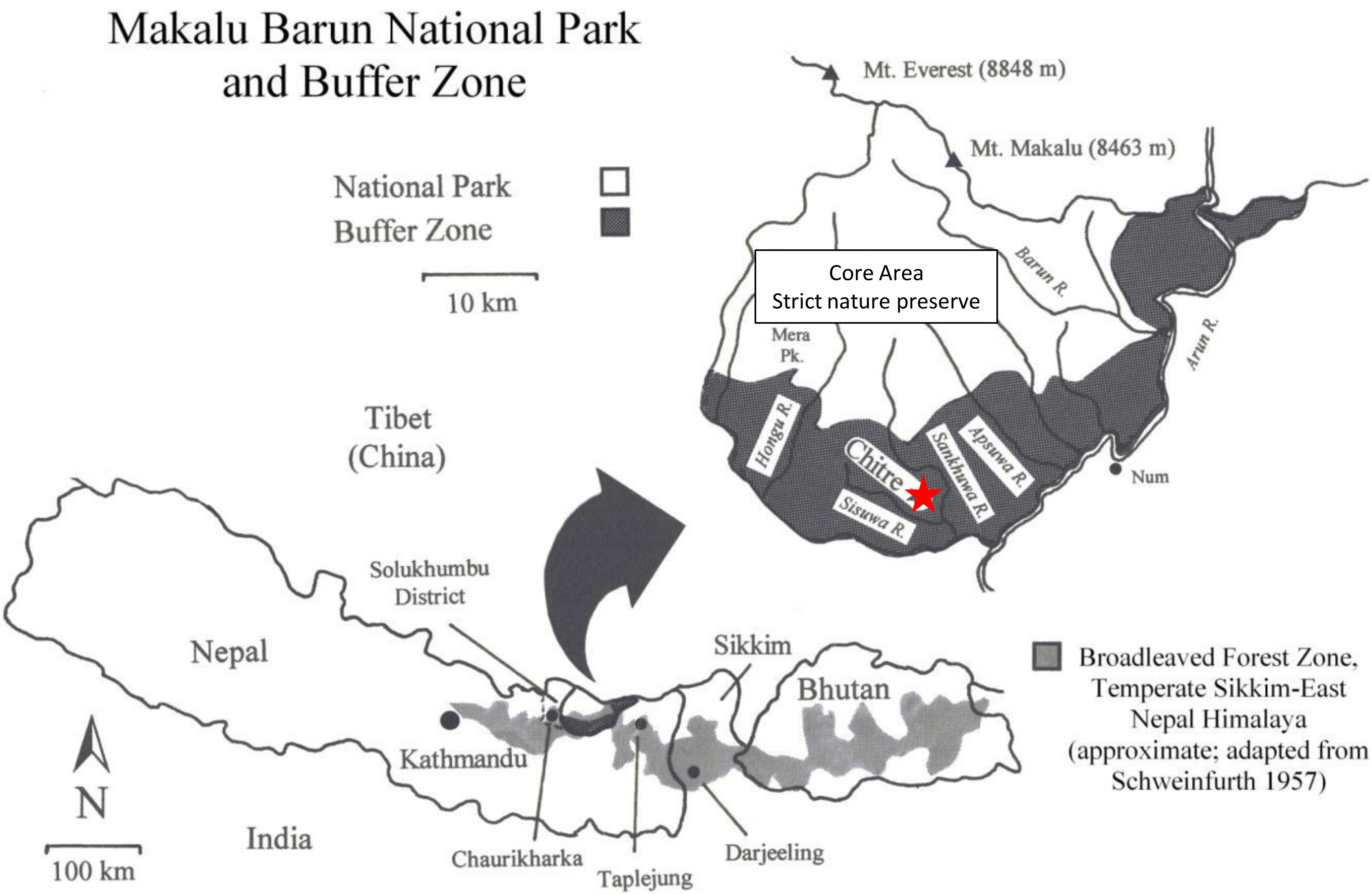
Indigenous Forest Use as an Agent of Change in Plant and Animal Communities of the Temperate Sikkim-East Nepal Himalaya

Himalaya Region




Makalu Barun National Park and Buffer Zone
National Park
Buffer Zone
10 km
Mt. Everest (8848 m)
Mt. Makalu (8463 m)
Core Area
Strict nature preserve
Barun R.
Arun R.
Mera Pk.
Hongu R.
Chitre
Sisuwa R.
Sankhuwa R.
Apsuwa R.
Num
Tibet (China)
Solukhumbu District
Nepal
Sikkim
Bhutan
Kathmandu
India
N
100 km
Chaurikharka
Taplejung
Darjeeling
Broadleaved Forest Zone, Temperate Sikkim-East Nepal Himalaya (approximate; adapted from Schweinfurth 1957)

Chitre Village: 10 households, 50 people

50 years ago, one of Earth’s most remote regions

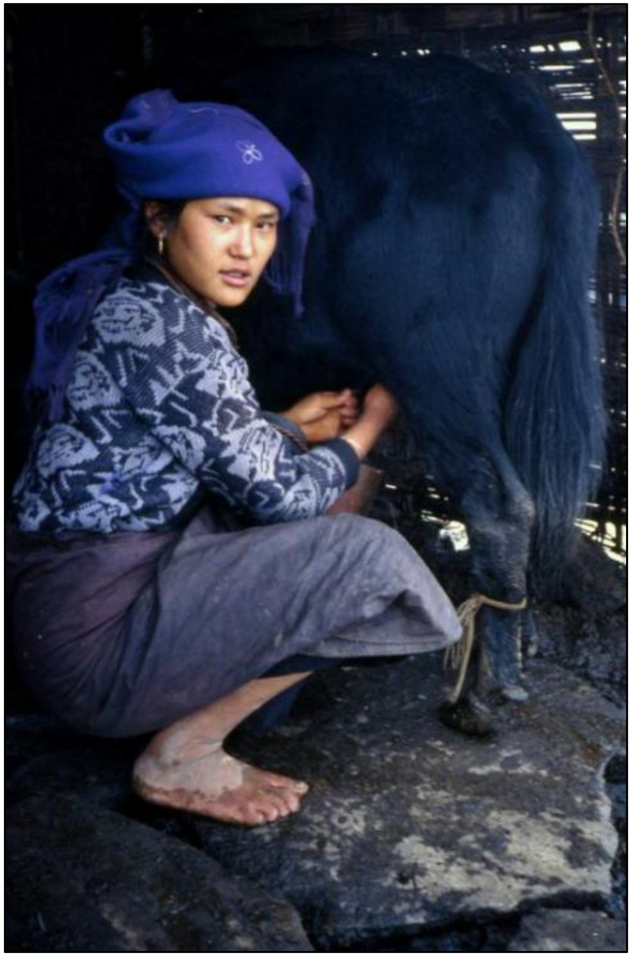
- Chitre is still the “last village” on the trail
- My first expedition required a 7-day walk from the nearest road

Monsoon climate: 12 ft annual precipitation, primarily April – September

Lies on the western edge of Eastern Himalaya Biodiversity Hotspot

- On the boundary of Palearctic and Oriental Biogeographic Regions
  - Broadleaved forests of the region are especially species-rich

Residents are Sherpas

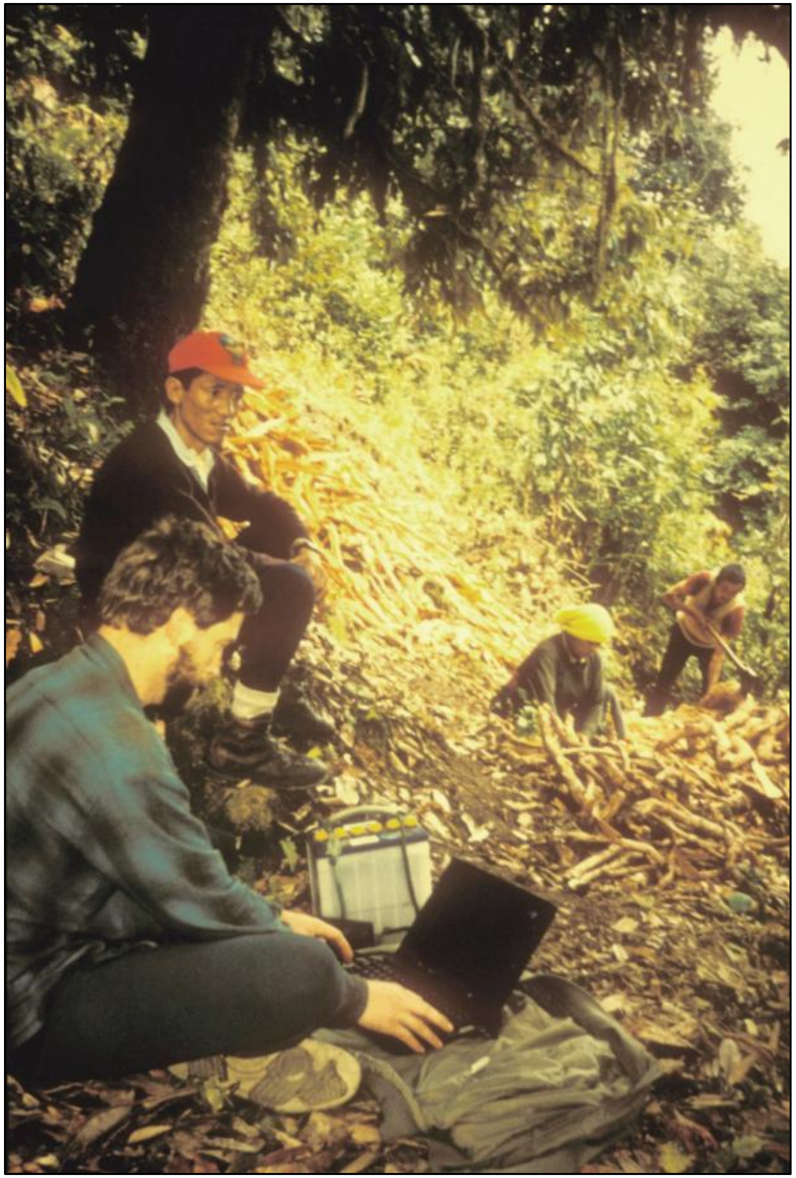


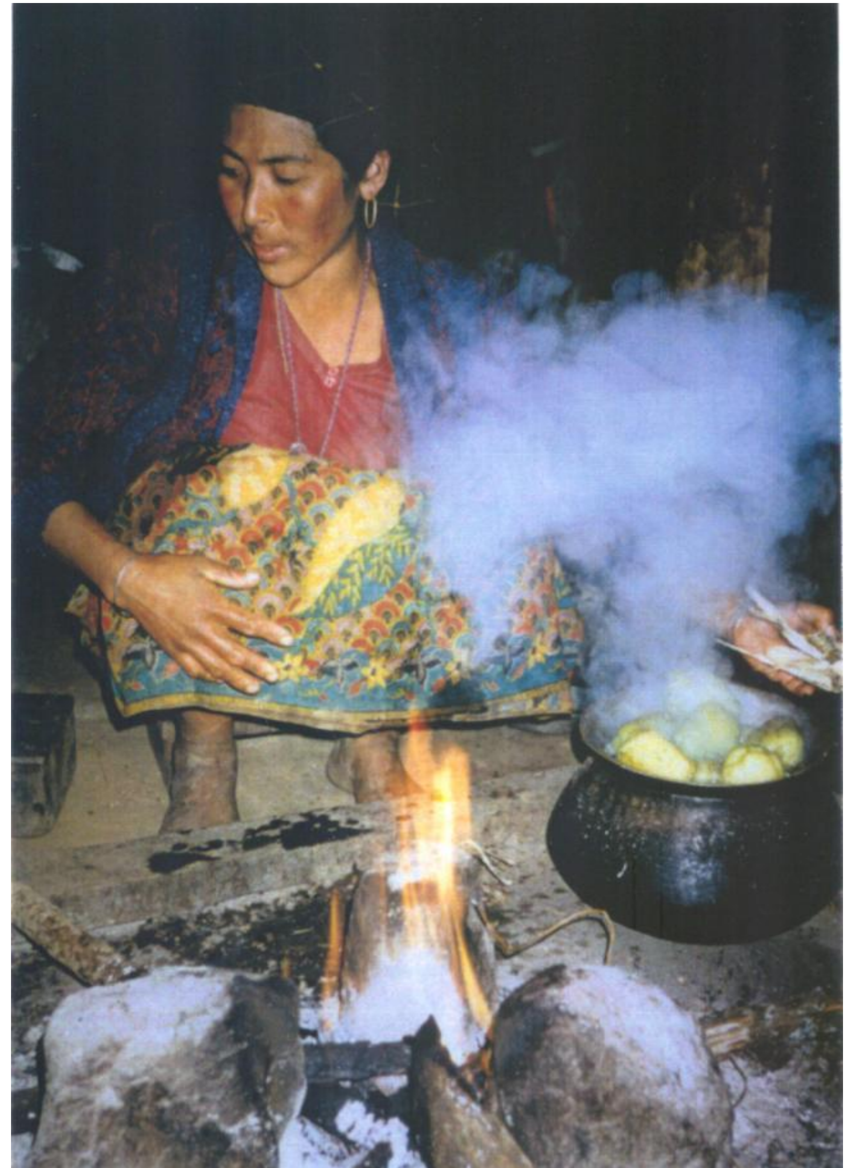
Tibetan cultural tradition, Nyingmapa (“red hat”) sect

Came to Solukhumbu (Everest) Region in mid-1500s, then spread

- Settled Chitre study site ~1915
  - Nearest neighbors are Kulungi Rais, with Animist/Hindu tradition

Subsistence livelihoods depend on forest biomass, e.g. fuelwood for cooking





Timber for “modern” buildings

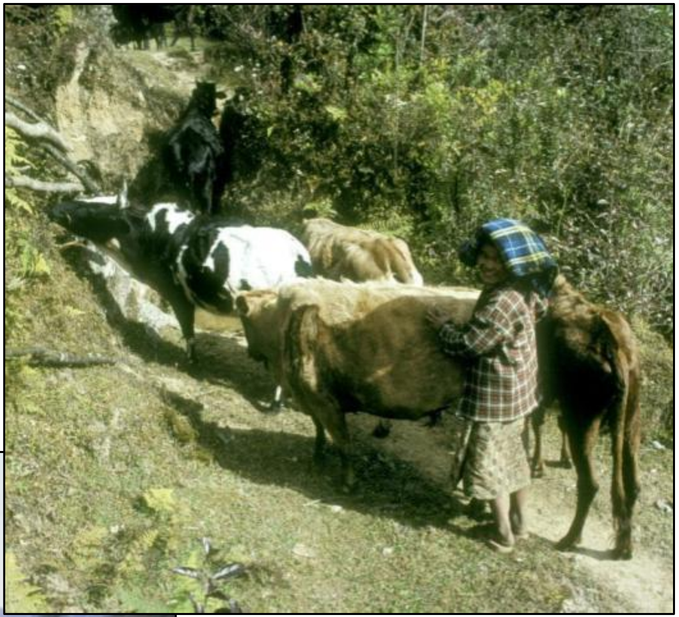
Bamboo for traditional structures, implements

Tree leaves for livestock fodder

Leaf litter for agricultural mulch (fertilizer)

Pasturage/browse for livestock

Itinerant *chau~ri* herds



Village-based herds

Over time, harvest of woody plants created a gradient of forest disturbance

<300 m of village center: croplands and dwellings

Most woody plants removed or eliminated by overharvest

200-400 m: shrubby pastures

High-value woody species overharvested, replaced by lower-quality xeric pioneers

300-650 m: secondary (disturbed) forest

- Some high-value species still available
- Dominated by mesic pioneers

>650 m: closed-canopy mixed broadleaved forest

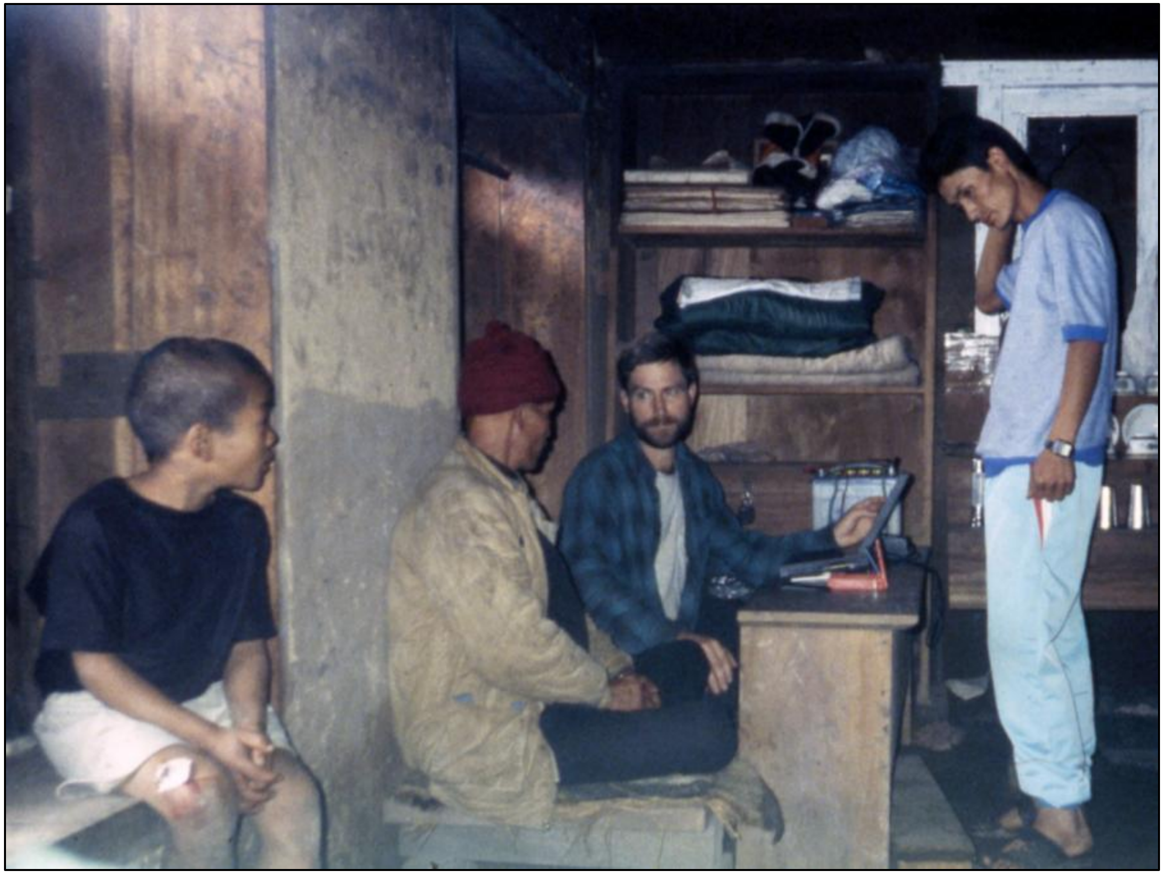
- High-value species still abundant
- >2000 m too remote for normal use

Collected field data for 18 months
Trained a local crew
Conducted all work in Nepali
Endured terrestrial leeches

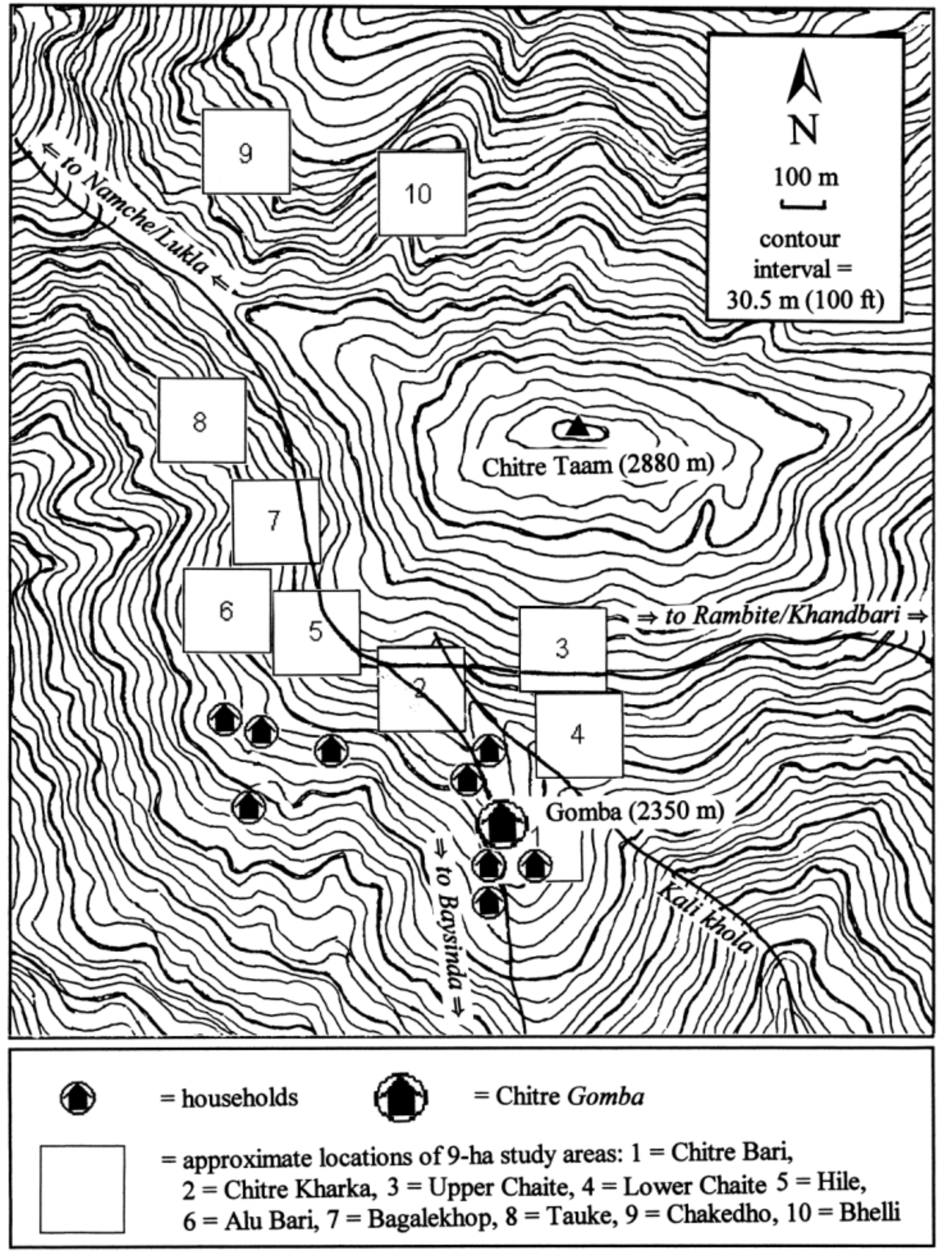
½ liter of leeches collected from my body during 3 months of bird survey work

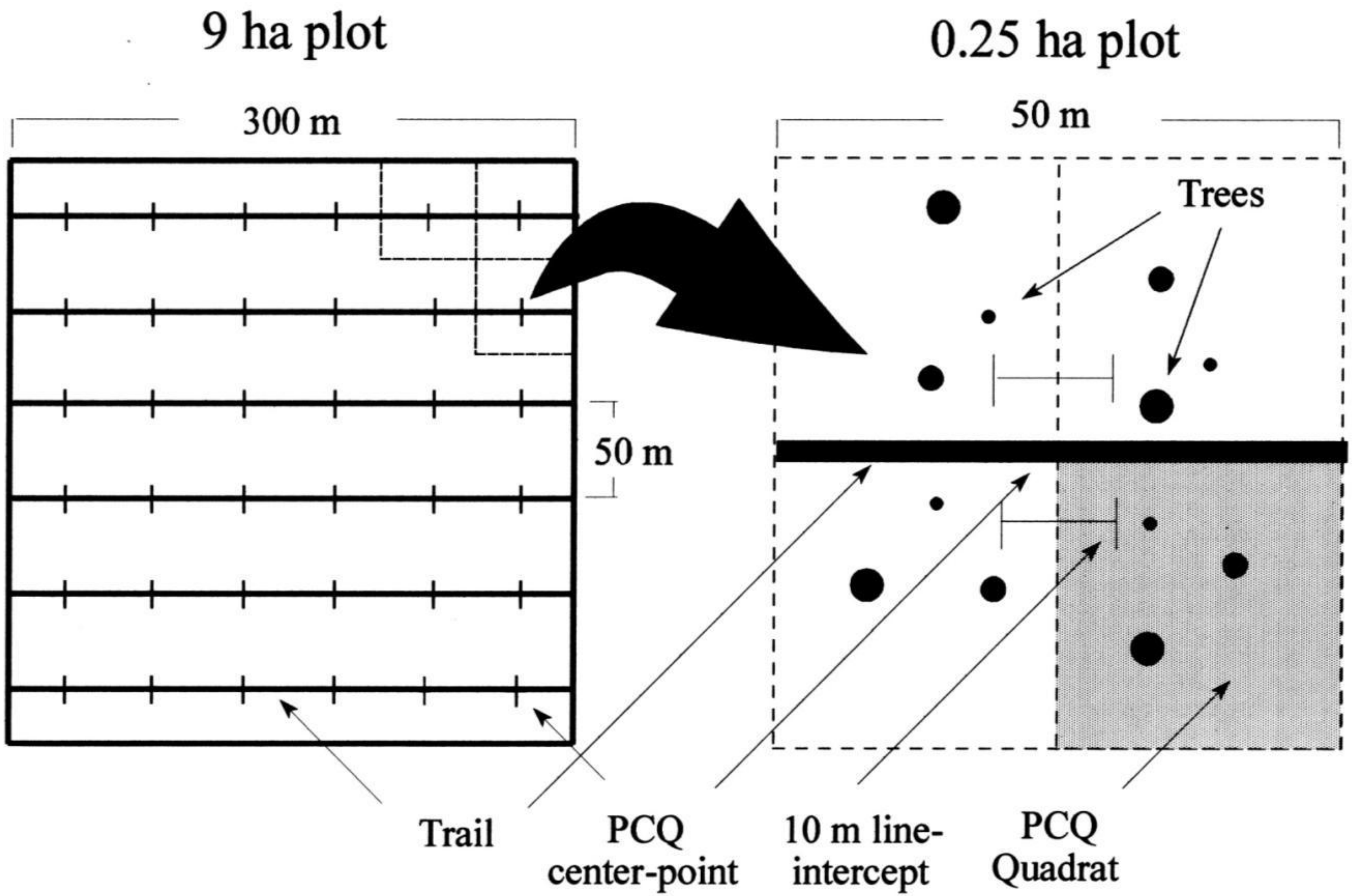
Monthly monitoring of household resource use

- Weighed fuelwood use on monthly sample days using Fox's weight survey technique
- Used recall survey technique for other resources



Placement of 9-ha study plots




9 ha plot
0.25 ha plot
300 m
50 m
Trees
50 m
Trail
PCQ
center-point
10 m line-
intercept
PCQ
Quadrat

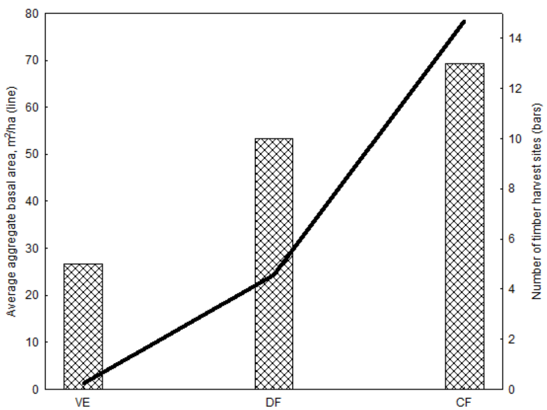
Detailed measurements of vegetation composition and structure

Sufficient data to reconstruct the 3-D architecture of the forest

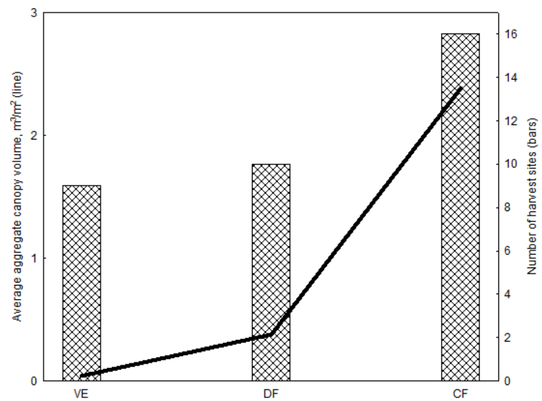
Findings: harvest and supply of high-value woody plants
(Bars, # of harvest sites; lines, supply; VE, near village; DF, secondary forest; CF, closed forest)

Overharvested nearby:

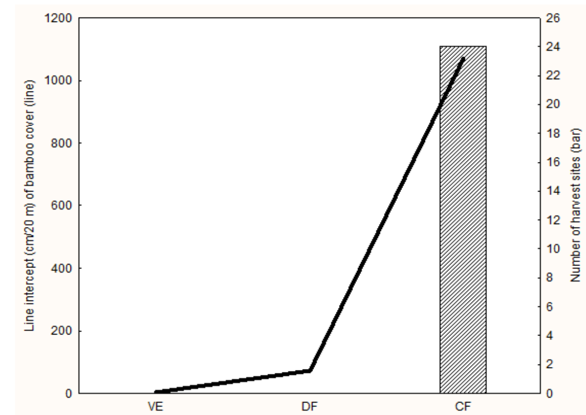
Timber



Tree fodder

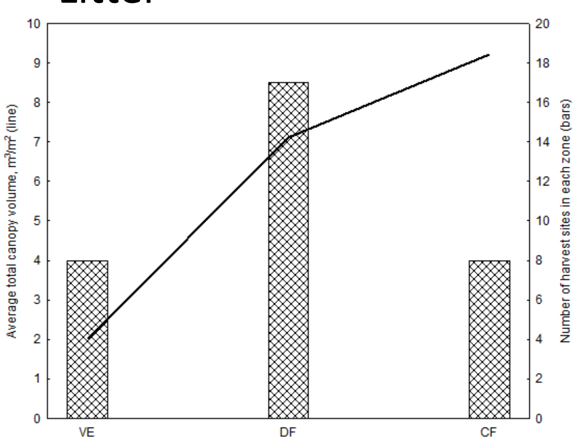


Bamboo

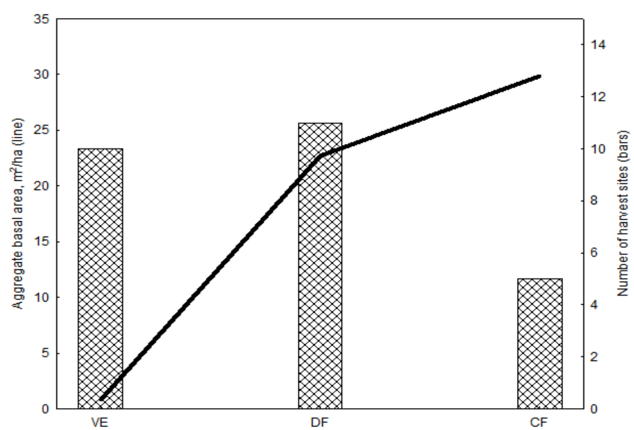


Available at mid-distance:

Litter

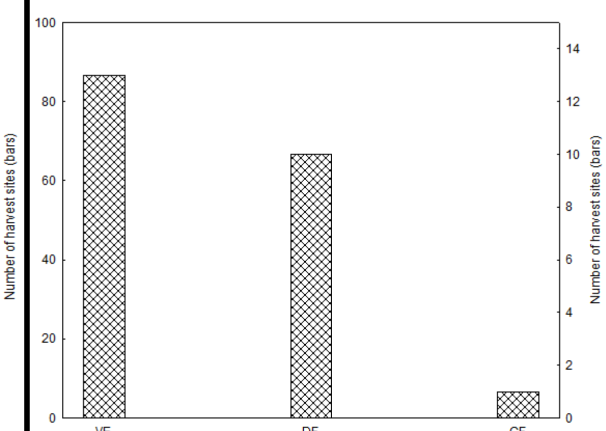


Fuelwood



Available nearby:

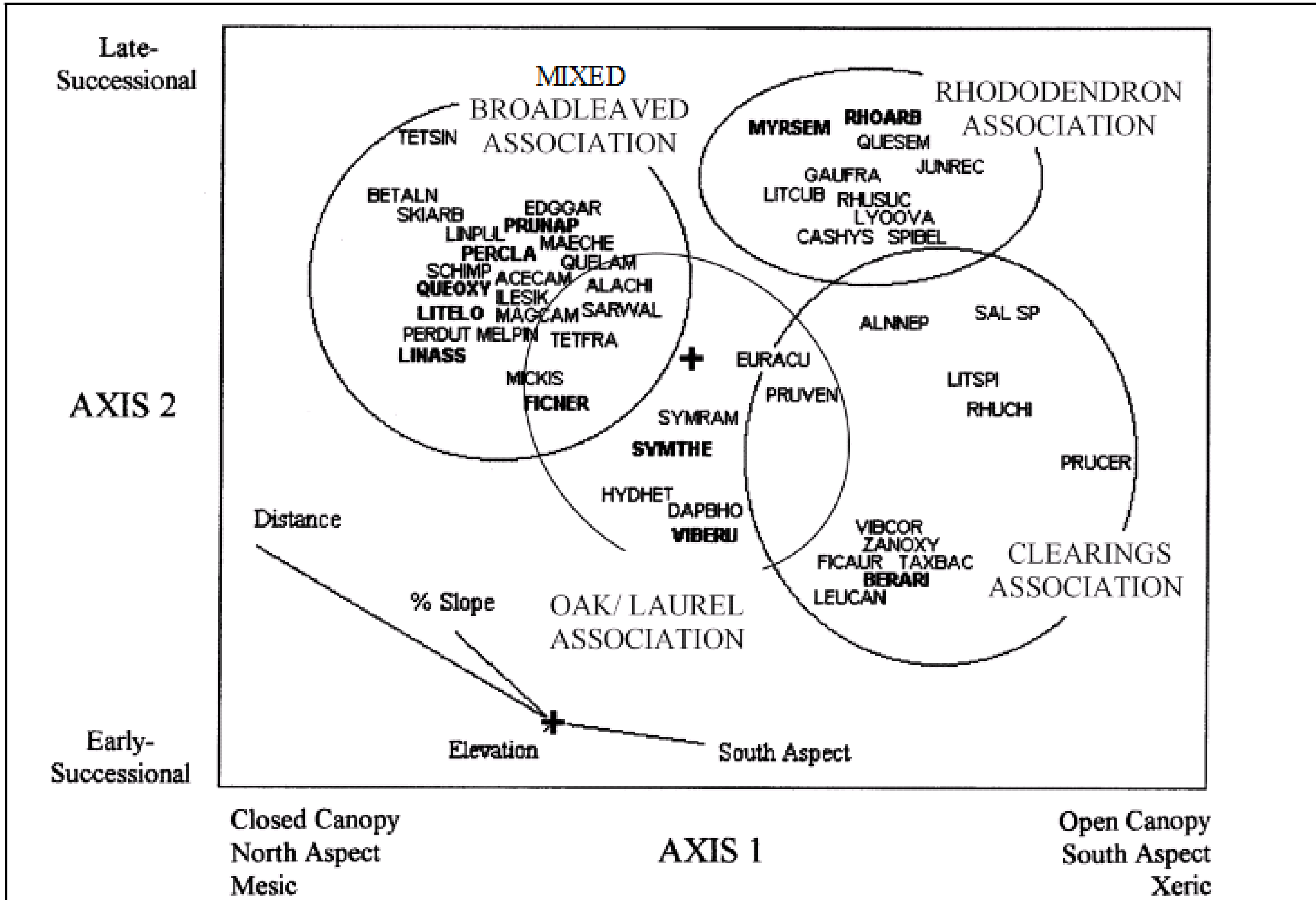
Pollarded stems



Environmental ordination indicates 4 plant associations (species groupings)

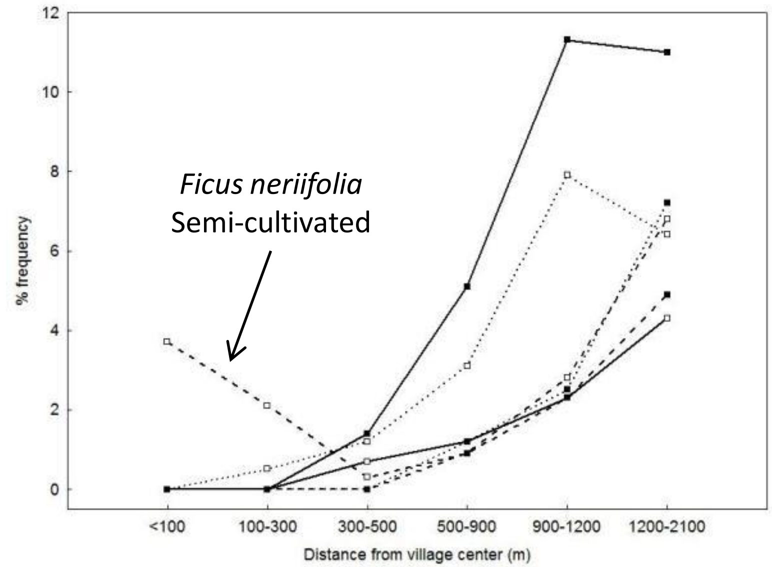
PCA Axis 1, moisture; Axis 2, successional status

Both axes are strongly influenced by forest use

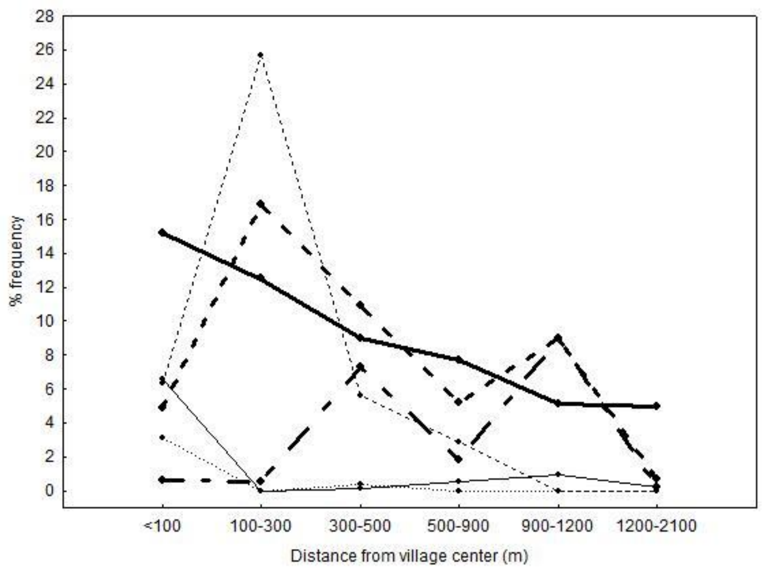


Distribution of successional types:

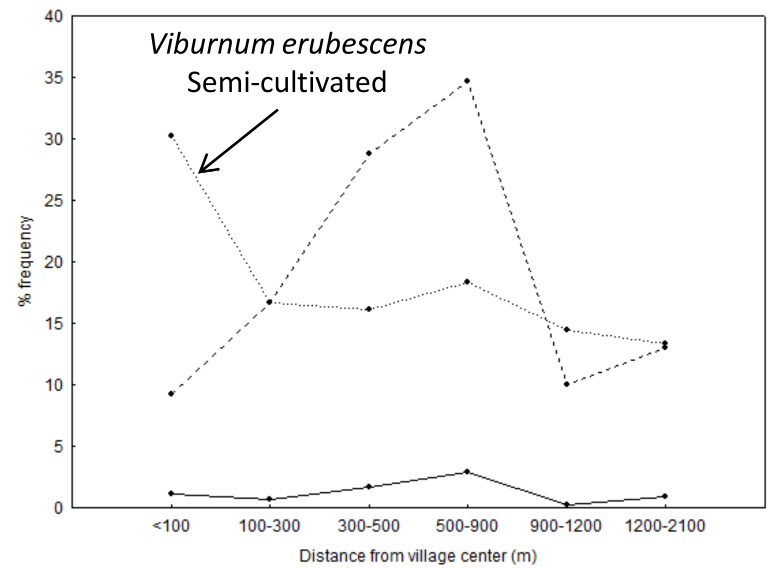
High value, late-successional



Xeric habitat pioneers



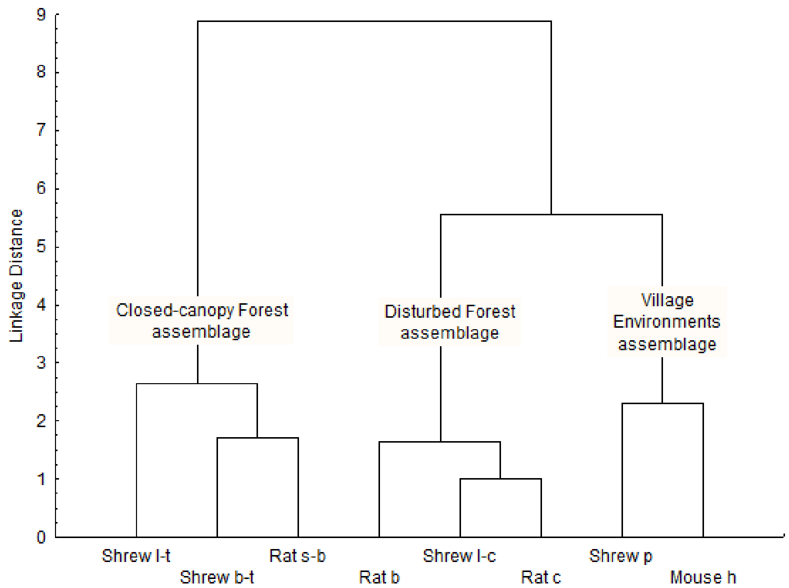
Mesic habitat pioneers



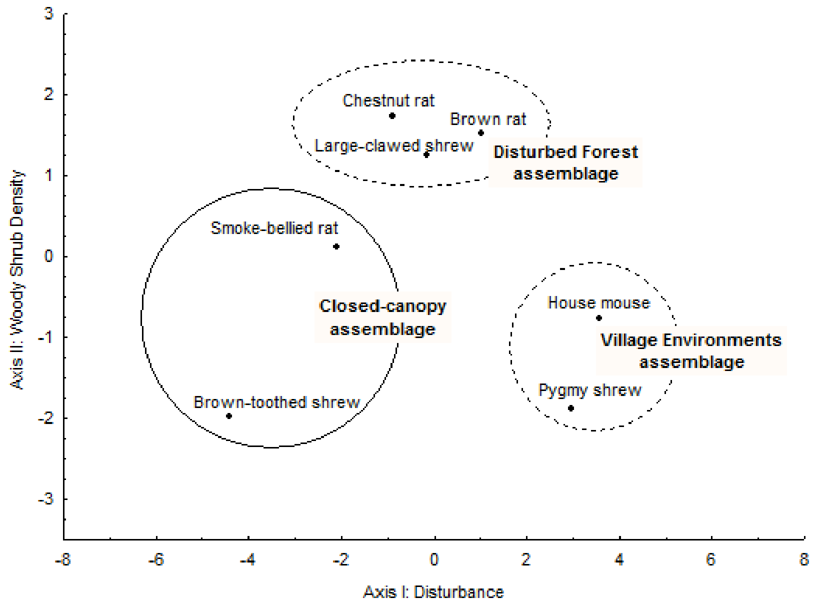
Collecting small mammal data

Himalayan pygmy shrew,
said to be smallest terrestrial mammal on earth

Environmental ordination of small mammals
3 ecological assemblages



Cluster analysis

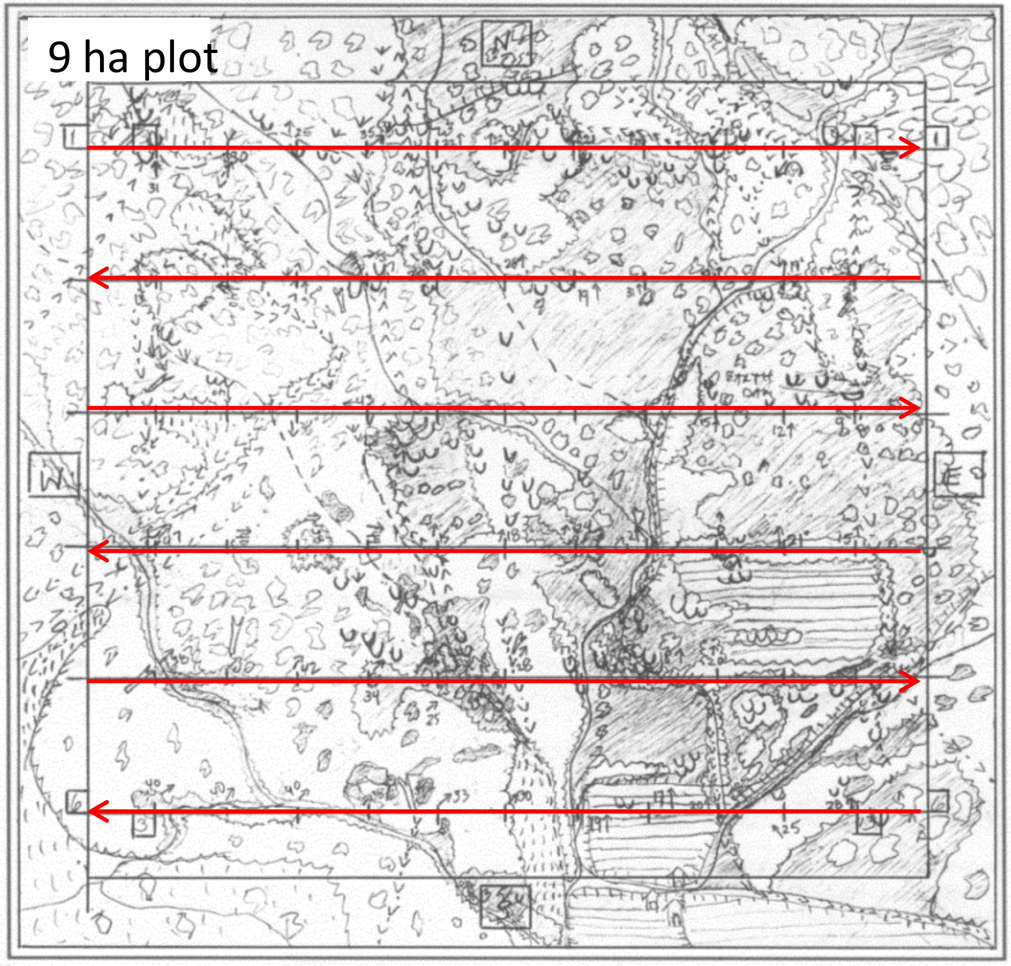


Principal Components

General bird surveys

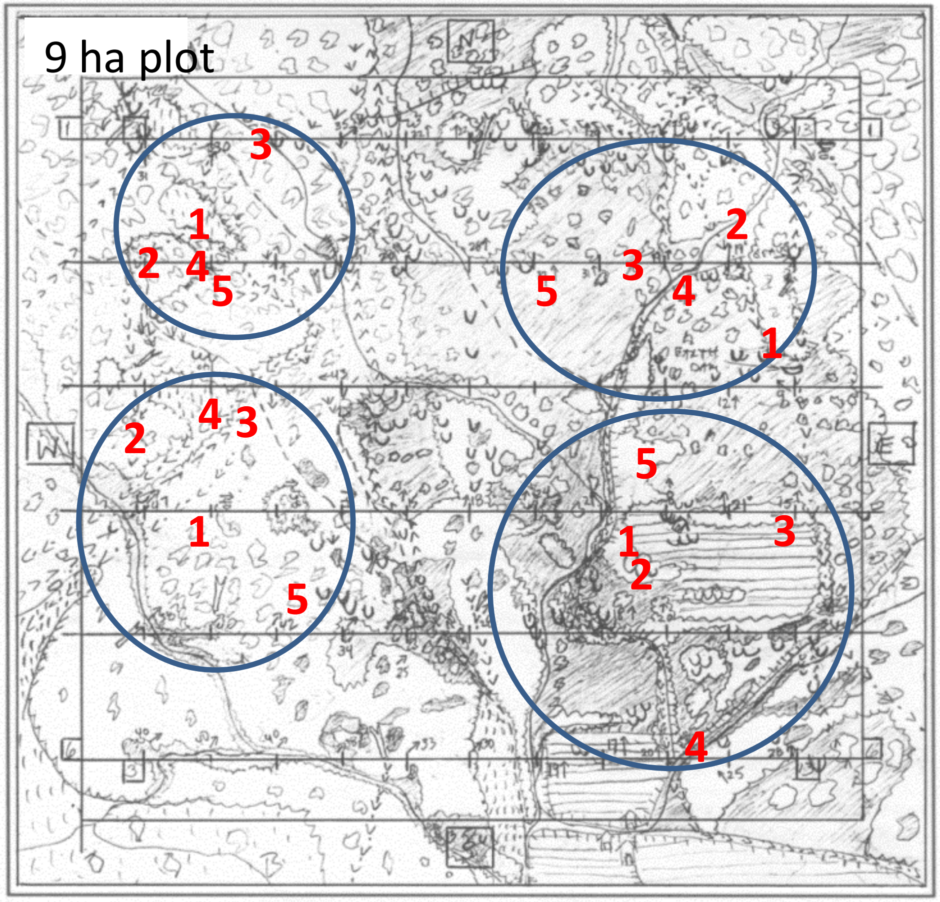
Transect counts along 6 trails per 9-ha plot, 5 repetiitons

No nocturnal species, high-flyers, etc.

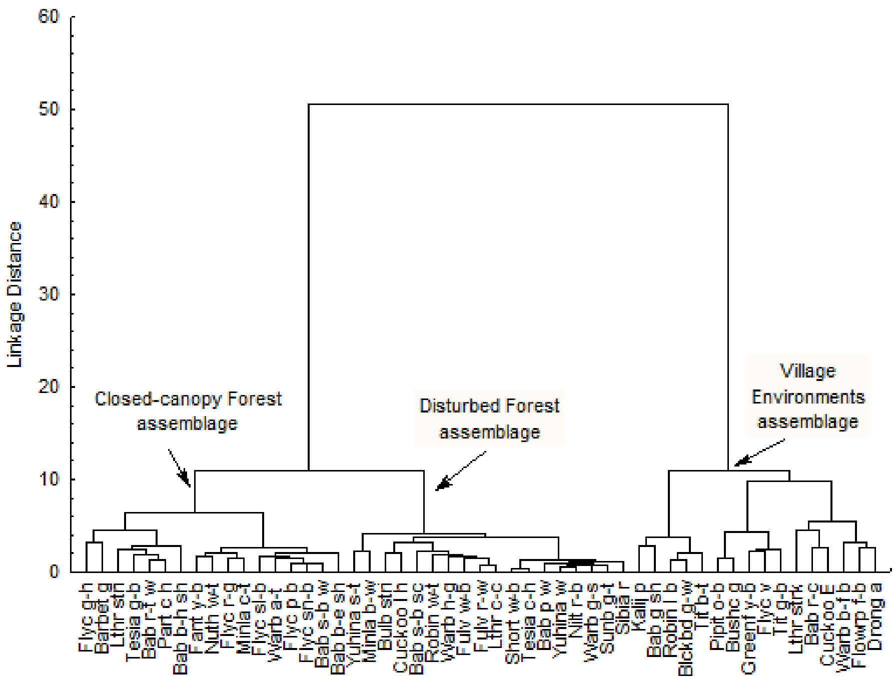


Territorial spot-mapping

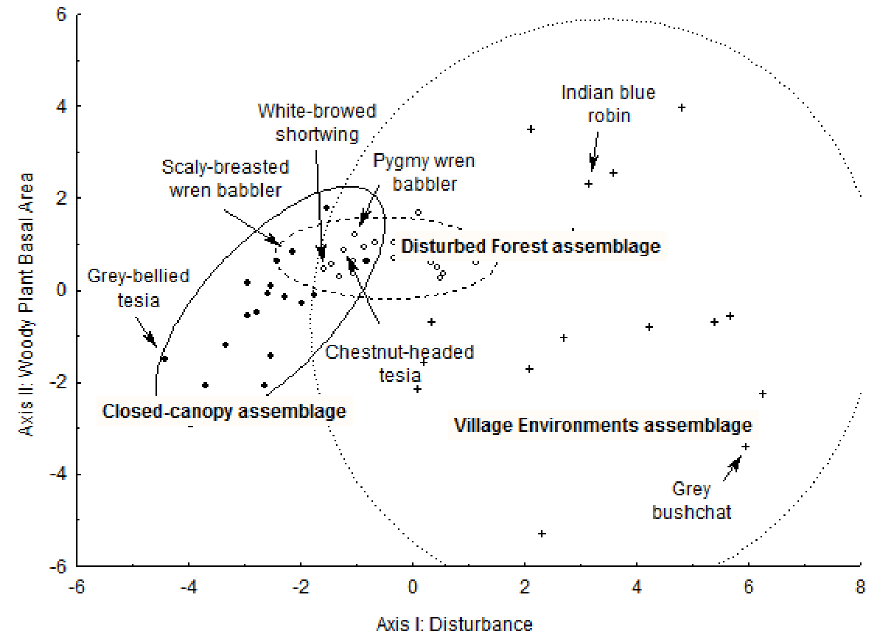
- 7 species of territorial songbirds
  - Plotting of repeated detections of signing males
- Produces higher quality data than transect counts
  - Known individuals, definitive habitat requirements for breeding
- Used for density estimates and logistic regression models of microhabitat



Environmental ordination of bird species
3 ecological assemblages



Cluster analysis



Principal components

Ecological guild analysis:

Diet
- Carnivorous (small animals)
- Insectivorous
- Frugivorous
- Granivorous
- Nectarivorous
- Herbivorous (leaves, buds)
- Omnivorous (grains, insects, leaves)

Foraging substrate
- Ground
- Shrub layer
- Mid-canopy
- High canopy

Nest type
- Open cup
- Domed
- Cavity
- Brood parasite

Nest placement
- Ground
- Shrub layer (<2 m ht)
- Mid-canopy (2-6 m ht)
- High canopy (>6 m ht)

Grey-bellied tesia (*Tesia cyaniventer*)

Indian blue robin (Luscinia brunnea)

Logistic models of species' microhabitat

C-h tesia: (+) associated with ferns, mesic pioneers, tall trees

(-) associated with xeric pioneers

TABLE 4.5.5. Best logistic regression models for chestnut-headed tesia microhabitat.

Model comparisons

Model	K^a	Likelihood[b]	Likelihood X^2	P	D/df^c	AIC_{cd}	ΔAIC_{ce}
FRN_COV[1], SYMRAM[Pa], EURACU[r]	3	-111.83	5.88	0.02	1.00	232.1	0.00
FRN_COV[1], SYMRAM[Pa], EURACU[r], LYOOVA[Pa],	4	-111.11	5.76	0.02	1.00	232.9	0.87
FRN_COV[1], SYMRAM[Pa], EURACU[r], LG_HT[r]	4	-111.78	5.94	0.01	1.00	234.3	2.20
FRN_COV[1], SYMRAM[Pa], EURACU[r], LG_HT[r], LYOOVA[Pa]	5	-111.10	5.79	0.02	1.00	235.3	3.24

Model parameter estimates

Model 1

Variable	Estimate	SE	Wald	P
FRN_COV[1]	0.684	0.18	14.38	0.00
SYMRAM[Pa]	0.820	0.34	5.78	0.02
EURACU[r]	-0.408	0.17	5.75	0.02

Model 2

Variable	Estimate	SE	Wald	P
FRN_COV[1]	0.589	0.21	8.13	0.00
SYMRAM[Pa]	0.828	0.33	6.21	0.01
EURACU[r]	-0.378	0.17	4.83	0.03
LYOOVA[Pa]	-0.121	0.37	0.11	ns

Model 3

Variable	Estimate	SE	Wald	P
FRN_COV[1]	0.649	0.21	9.59	0.00
SYMRAM[Pa]	0.824	0.34	5.87	0.02
EURACU[r]	-0.387	0.17	5.28	0.02
LG_HT[r]	0.014	0.04	0.10	ns

Model 4

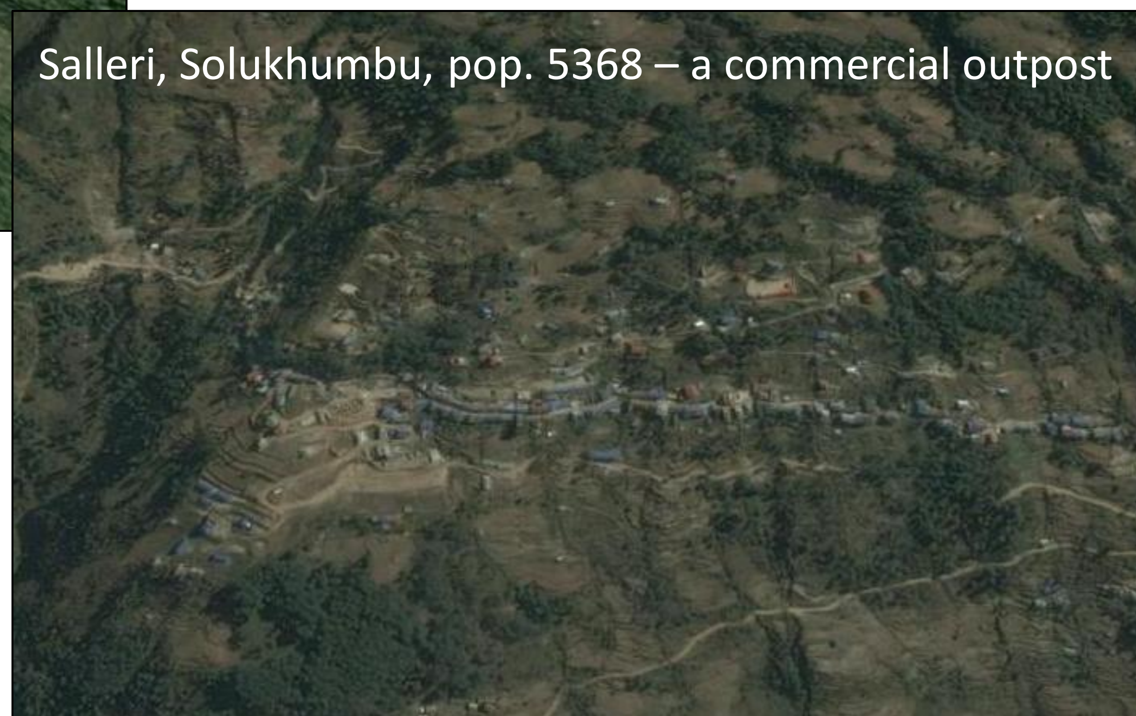
Variable	Estimate	SE	Wald	P
FRN_COV[1]	0.576	0.23	6.15	0.01
SYMRAM[Pa]	0.829	0.33	6.22	0.01
EURACU[r]	-0.374	0.18	4.58	0.03
LG_HT[r]	0.006	0.04	0.02	ns
LYOOVA[Pa]	-0.123	0.37	0.11	ns

[a] Number of model parameters, excluding intercept and maximum $K+1 < n/10$; [b] Log-likelihood, [c] Deviance/df; [d] AIC_c referenced to model with all listed variables; [e] Deviation from AIC_c of best model; [1] Ln(x+0.5) transformed; [Pa] Dichotomized (presence-absence), [r] Raw data.

Broader perspective:

- Used data from Chitre to model anthropogenic change in Temperate broadleaved forest
  - Made use of “photorealistic” terrain visualization software
  - Purpose: to understand and potentially managing ecological change

How will ecological communities change as a village like Chitre becomes like Salleri?



Stage 1: seasonal kharka

Patch-scale components:

Primary forest patch

Forest-interior kharka

Extensive primary forest

Use is seasonal

- Limited to trails and kharkas
- Species of disturbed habitats are rare

Seasonal kharka stage compared to later stages, based on Chitre data

Woody plants:

- Species diversity (H’) relatively high - rare species well represented
- Late-successional species relatively frequent
- Pioneer species relatively infrequent – predominantly mesic gap pioneers

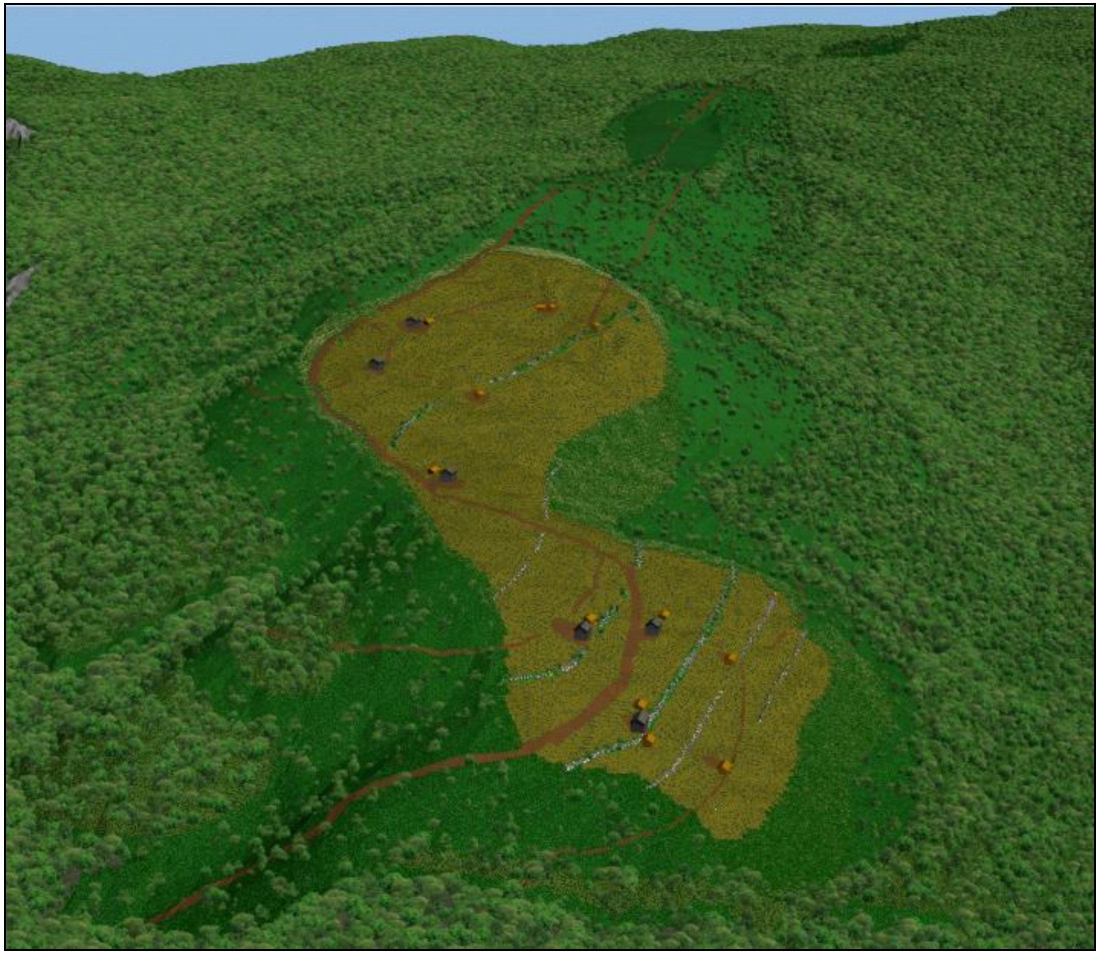
Animals:

- Species diversity (H’) intermediate
- Bird guilds best represented:
  - Strict frugivores & nectarivores
  - High canopy foragers
  - Mid-canopy foragers & nesters
  - Shrub canopy nesters
- Large hunted species relatively abundant

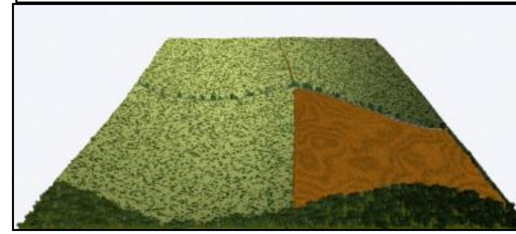
Satyr tragopan (*Tragopan satyra*)

Barking deer (*Muntiacus muntjak*)

Stage 2: small village (e.g., Chitre)



Cropland patch



Pasture patch

Fuelwood harvest patch

Timber harvest patch

Areas of cropland, swidden, pasture, secondary forest
High-value species are overharvested near village
Primary forest still easily accessible

Species diversity at the small village stage (compared to other stages):

Animal diversity peaks, because habitat diversity peaks

- In accordance with Intermediate Disturbance Hypothesis

Influx of generalists associated with open, xeric, habitats of lower elevations

Canopy openings increase habitat for shrub foragers & nesters, insectivores, herbivores

Pass-through migrants find more grasses, fruits, flowers

Large hunted species are rare or extirpated

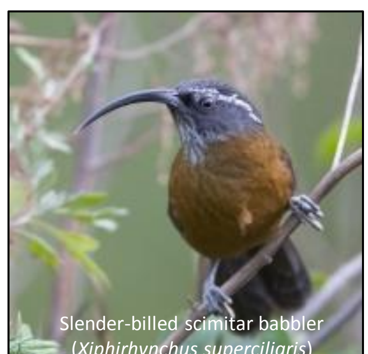
Xeric generalists

Grey bushchat (*Saxicola ferrea*)

House mouse (*Mus musculus*)

Shrub nesters

White-browed fulvetta (*Alcippe vinipectus*)



Slender-billed scimitar babbler (*Xiphirhynchus superciliaris*)

Pass-through migrants

Fire-tailed sunbird (*Aethopyga ignicauda*)

Dark-breasted rosefinch (*Carpodacus nipalensis*)

Stage 3: commercial outpost (e.g., Salleri)

Dominated by cropland, swidden, and secondary forest
Primary forest reduced to small remnants at inaccessible locations
Diverse human cultures and livelihoods, motorable road and commerce
Timber unavailable locally, trucked in
Gully erosion due to forest loss and grazing

Overall pattern: "biological homoginization"

Uniqueness lost, area biotas become similar

<u>Winners</u>

- Among woody plants
  - Pioneer species, mesic and xeric
  - Browse-tolerant species
- Among animals
  - Widespread, generalist, xeric species
  - Shrub nesters and foragers
  - Omnivores, granivores

Berberis aristida

Ashy drongo
(*Dicrurus leucophaeus*)

<u>Losers</u>

- Among woody plants
  - Late-successional species
  - High-value species
  - Palatable species
- Among animals
  - Endemic habitat or dietary specialists
  - Forest-interior species
  - Ground & mid-canopy foragers & nesters
  - Nectarivores, insectivores, frugivores
  - Large species (ungulates, pheasants)

Persea clarkeana

Ashy wood pigeon
(*Columba pulchricollis*)

Synopsis, major accomplishments:

- Analyzed composition of historic forest from relict stumps and trees
- Analyzed vegetation associations formed by anthropogenic disturbance
- Conducted multivariate habitat analysis for little-known animal species
- Used spot-mapping to determine breeding densities and microhabitats (Design II habitat analysis)
- Conducted habitat modeling with binary logistic regression
- Established quantitative links between resource harvest and ecological change
- Created models of landscape/habitat change using visualization software

All are novel for the moist-temperate Himalaya

All are essentially untouched in the region since my work at Chitre

One bird habitat study in Sikkim – less rigorous, less depth

Such data-driven research is frequently cited as essential for biodiversity conservation

But very little has been done

I've provided some of the ecological knowledge necessary for biodiversity conservation under the forest co-management paradigm, whereby local people conduct most on-the-ground conservation. Much more scientific knowledge must be collected and integrated into co-management to achieve real biodiversity conservation, however.

Buddhist communities will likely be the most receptive to biodiversity conservation
- Harmony with other organisms is a basic tenet of their traditional teachings