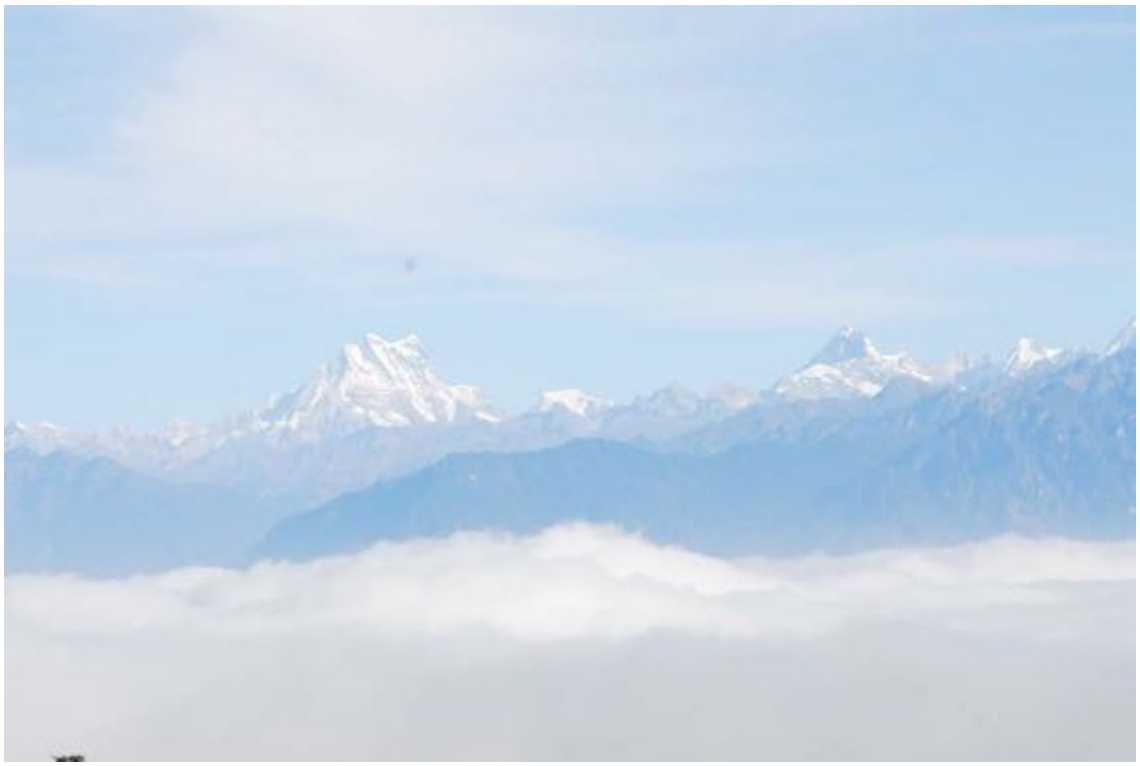
The design of the National Forest Inventory for the Royal Government of Bhutan

Below: view of Mt. Everest on Drukair (national airline) flight from Kathmandu, Nepal to Paro, Bhutan



Dr Zakir Hussain entered Yale PhD program in 1981 and received his PhD in 1986. He was a student of D. M. Smith.

TGG was here 1980 - 1985, working with George Furnival.

Zakir joined the Asia Regional office of IUCN in Bangkok in 1991, and apparently still works for IUCN.

Maung Moe (Moe) Myint got his Doctor of Science degree in 1996 from Asian Institute of Technology in Bangkok. His speciality was and still is GIS and RS.

He knew Zakir because Moe's wife, Yu Yu, was chief accountant at Asia Regional Office before getting promoted and relocated to IUCN headquarters in Gland, Switzerland.

Moe and Yu Yu both are natives of Myanmar, but emigrated to be based in Bangkok. However, Moe was funded on special projects in Bhutan by various international aid agencies from Sweden, The Netherlands, Denmark. All made use of Moe's GIS and RS skills.

Nonetheless, Moe felt a need for more advanced training and study in statistics. So, Zakir told him to that he needed to go study with Tim at Yale, to which I had returned in 1998.

So, Moe applied for the midcareer MF degree program, and received the MF1 degree in May 2008. In every course he took at FES, he received Honors grade! These included my courses in regression, sampling, and spatial statistics. (Moe was a precursor to Kezang, except that Kezang also took Dana's GIS courses!)

Moe was also close personal friend of Lyonpo Pema, the Minister of Agriculture and Forests (MoAF) at the time.

Bhutan had just voted and approved its first constitution in 2008, which commits Bhutan to maintain 60% forest cover in perpetuity.

In January 2009, we held a multi-stakeholder workshop, with the blessing and approval of MoAF, to which we invited public and private agencies to float the idea of a modern, comprehensive national forest inventory for the Bhutan.

Moe had named it the Data Users Consultation Workshop.

Below, the opening ceremony just prior to blessing by the monks on the right.

Here is group pic... Lyonpo Pema and me in the middle, Moe in blue tie, next to Margaret from the Dutch SNV agency which funded this workshop.

Note, Kezang had not yet been assigned to NFI.

After opening ceremonies, I addressed the group with

Reflections on the Process of Designing a National Forest Inventory for Bhutan

January 2009

It was very important to me, both professionally and personally, that this not be perceived merely as a timber inventory, but rather as a modern, comprehensive land inventory for RGOB.

On the next page is an excerpt from the address.

Of the 10 Ways two are particularly important:

- nationally consistent estimates of prescribed core variables
- publication of these estimates at prescribed intervals

Transparancy and ongoing communication is essential to the success of this endeavor, beginning with the planning, extending to the documentation of methods (design, measurement protocol, estimation), and ending with the presentation of results... all in an effort to ensure a common understanding and to foster acceptance of inventory outcomes.

As a first step in the communication, the designers of the NFI must learn the needs and expectations of the user community. Needs and expectations are dynamic, and will change over time.

TGG had studied and written about inventory and sampling for 30+ years by then... **but** I had never actually designed a national inventory!

I did not want to come into this to dictate how I thought it should be done.

We broke off into small working groups, to address the issue of "if we do this, what are the attributes that you need to have measured?"

I posed some initial questions to be answered in the workshop (see next page) to get the discussions started among the groups.

(Starter set of) Questions requiring answers

Who are the principal stakeholders and clients?

From National Forest Code for Bhutan, “NFI would encompass the forests, pastures, agricultural land etc...”. True? (All elevations? Permafrost? Inaccessible?)

Uniform sampling intensity in all land cover classes and land use classes?

What is forest land? (definitions vary around the world)

How to record forest condition?

Periodic or annualized design?

Single plots or clusters of plots?

How to deal with plots crossing forest condition classes? (Part of plot is in a lake, or a pasture, or a road).

Stem volume equations for all species needed?

Aboveground biomass equations (including branch, bark, foliage) for all species needed?

Responsibility for establishing measurement protocols, provide training to field crews, quality assurance?

Time frame for planning?

Time frame for training and pilot study?

When I left Bhutan a week later, the NFI had been launched with great and widespread support.

We had decided on a 4 × 4 km square grid over the entire nation.

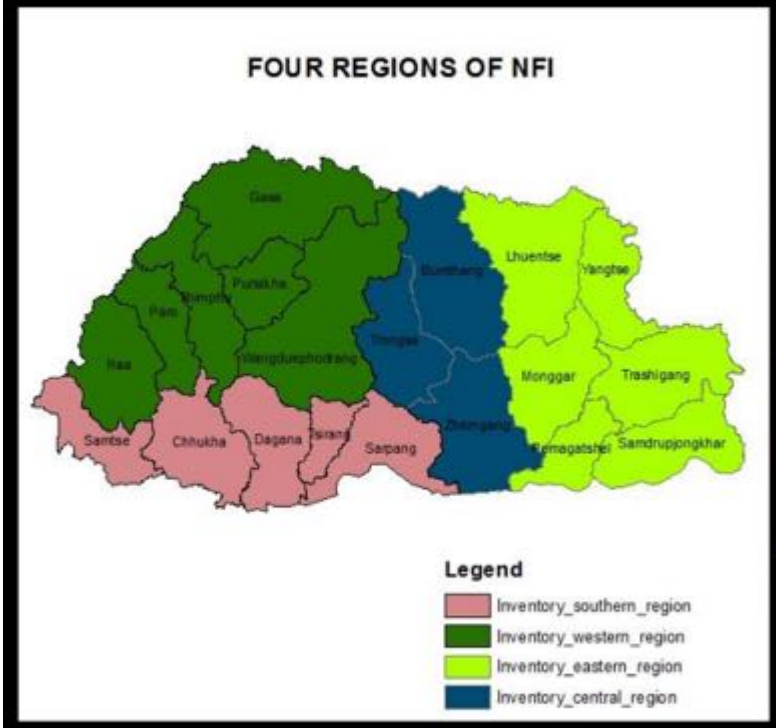
We had decided on the plot design (details below), and many other issues. Admittedly, a lot of details still needed to be addressed by the soon-to-be NFI staff, including $$ to pay for NFI!!

Kezang came on board shortly thereafter, and was assigned to be Coordinator of NFI.

Many of you are aware of my high esteem for Kezang's abilities. In my recommendation for midcareer admission I wrote that “It is because of Kezang that the NFI got accomplished.” While there are other players, of course, I do not think that admiration for Kezang is an overstatement to this day.

A google search found this 2013 pub that I had not been aware of. I like it because it provides a concreteness to the magnitude of the NFI effort.

Implementation modality for NFI



Twelve Inventory Crews , comprising of five foresters each trained(60 field crews in total)

Field work to be carried out region wise.

Time frame of two years

Cost of field work only: 52 million ngultrum

Thursday, October 17, 2013

Department of Forests and Park Services
Ministry of Agriculture and Forests

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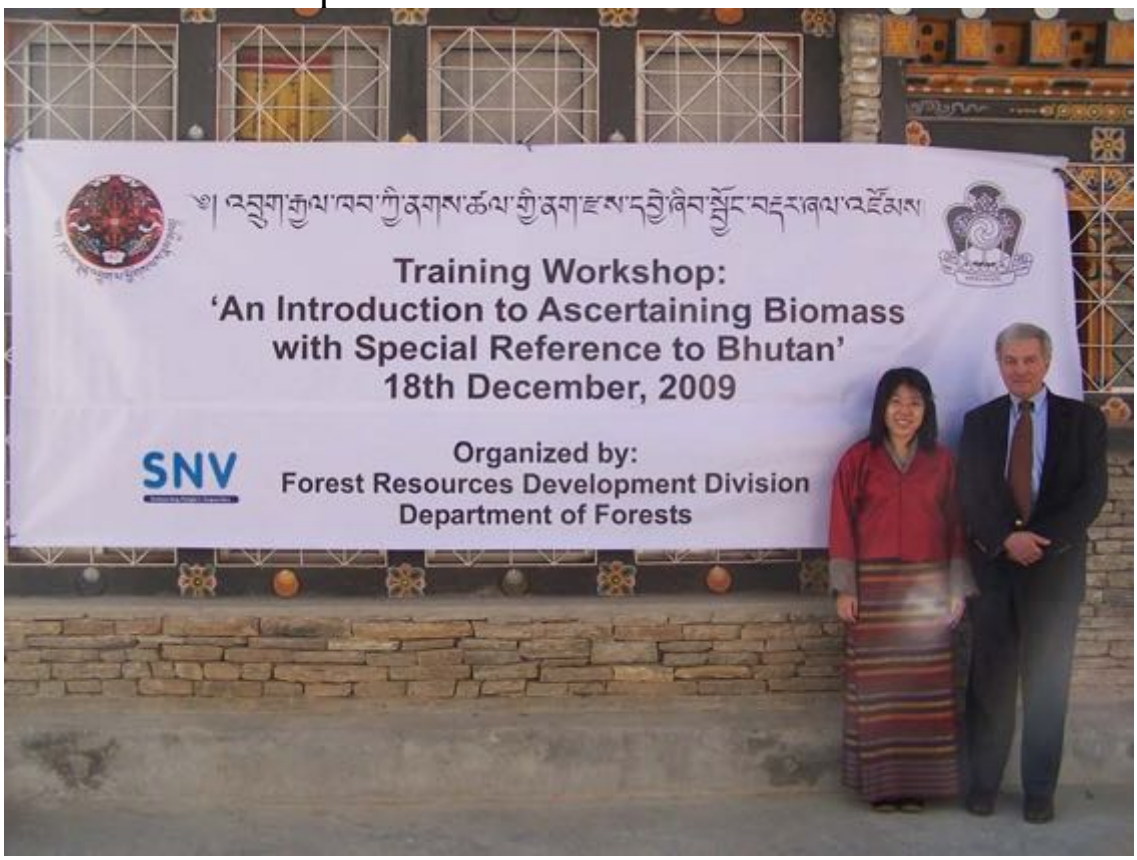
A point of discussion was development of allometric models to enable individual-tree prediction of abovegrond biomass (AGB).

I was back in December 2009 to present, again with Moe's help, a Biomass Workshop.



And by now Kezang and Younten (who will be here next year as midcareer student) have joined by then.

You can see Sonam Choden in back row, and I can recognize others who have been valuable aids to Kezang and Younten.

This workshop had in the field training on randomized branch sampling. Another, more intense field training was conducted by Moe, Kezang, and me a couple years later. Omitted from this pic is the one where we are all drinking milk tea from china cups in the field!

Ministry officials decided that Bhutan must develop its own allometric equations – 50 species or groups of species, and a minimum of 30 destructively sampled trees for each. This effort, funded by World Bank (I think), is underway still. It is a huge collateral effort to the main NFI field work and plot system.

As a result of the second training session in 2011

Training Workshop
for
Biomass Equations for Bhutan

Ministry of Agriculture and Forestry
Forest Resources Development Division

19-28 July 2011

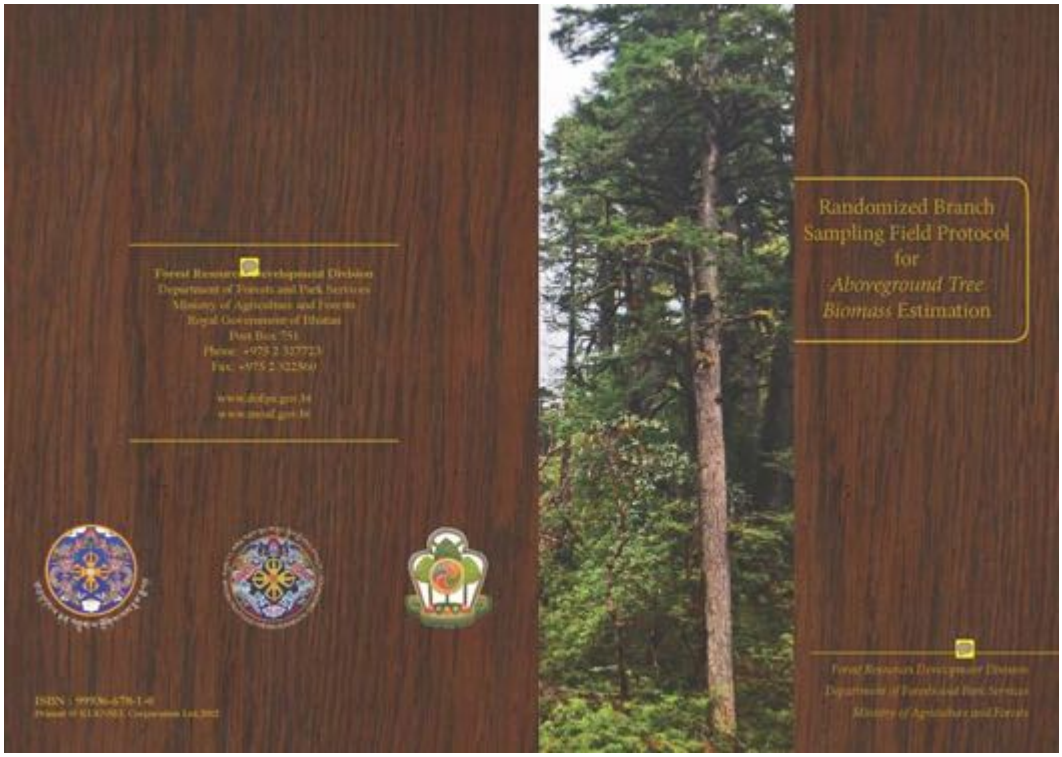
with support from the
Bhutan Trust Fund for Environmental Conservation

Presentations and field exercises conducted by

Dr. Timothy G Gregoire, Professor
Dr. Moe Myint, Research Scientist

Yale University
School of Forestry & Environmental Studies

Subsequent to that training, Kezang and I wrote this field protocol manual (see did the graphic design work!).



Also in May 2011, Kezang, Younten and three others came to FES for the entire month.

Five days each week, 8am to 6pm each day, I gave essentially my fall regression course in four weeks. Morning lectures, with Moe guiding them through exercises in the afternoon. (With a few weekend trips to Clinton outlets, that I was not a part of!).

They worked diligently on stuff that is not easy for most.

Kezang learned it again last year, and Younten will in fall 2017.

Bhutan's terrain is challenging in many places. In the north there are glaciers, in the south's semi-tropical forests there are elephants, wild boars, snakes, leeches. And everywhere there are coursing rivers and bears.

The first phase of training included 12 crew leaders with five field officers (foresters) and social scientists from Washington University and Yale University serving as consultants. Netherlands Development Organization (SNV) and the consultants helped with statistical inputs. After a three-year gap, a second training was held in April 2012. In July 2012, field work began but was suspended due to limited funding.

Difficult terrain and landscapes for field work (Courtesy of FRMD, Bhutan)

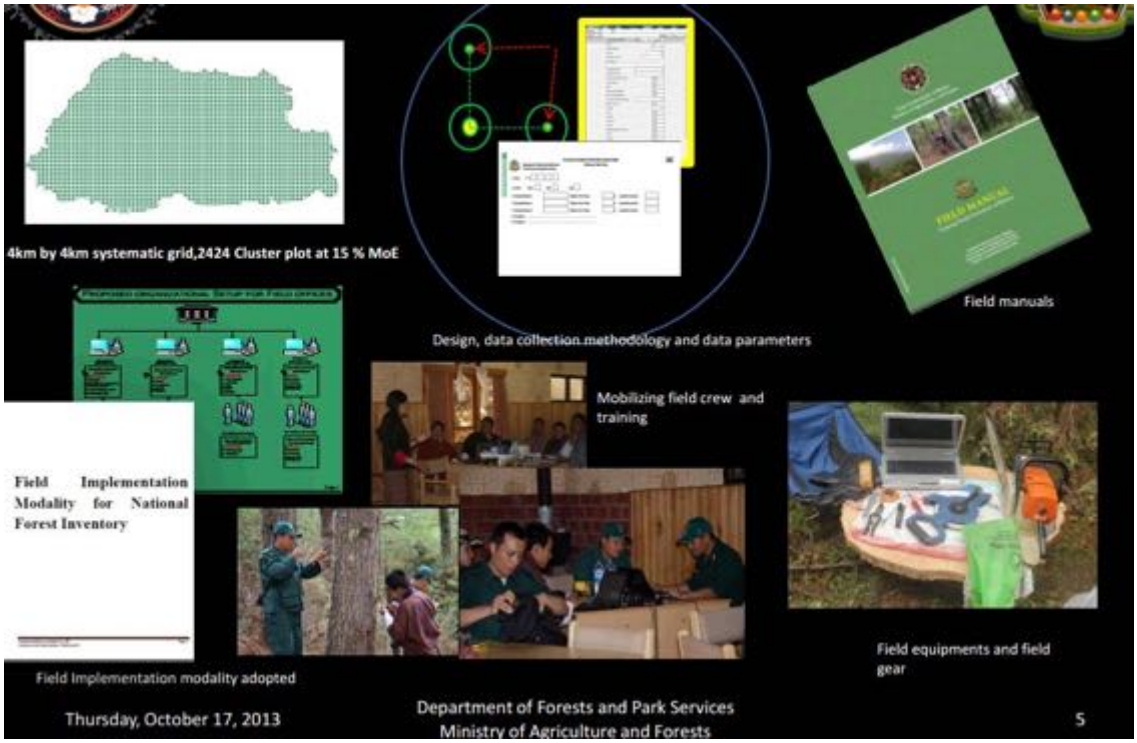
BHUTAN

High price to pay for Bhutan's forest inventory

By Tshering Palden
02 February 2016
Kuensel (Buthan)
#Environment

THIMPHU (Kuensel/ANN) - Bhutan's first national forest inventory shows the country boasts of more than 70 per cent of forest cover, but it resulted in the death of a ranger.

The National Forest Inventory, the fieldwork for which concluded a month ago, claimed a life and many narrowly escaped death treading over cliffs, glaciers, in extreme weather conditions.


4km by 4km systematic grid,2424 Cluster plot at 15 % MoE
Design, data collection methodology and data parameters
Field manuals
Field Implementation Modality for National Forest Inventory
Mobilizing field crew and training
Field Implementation modality adopted
Field equipments and field gear
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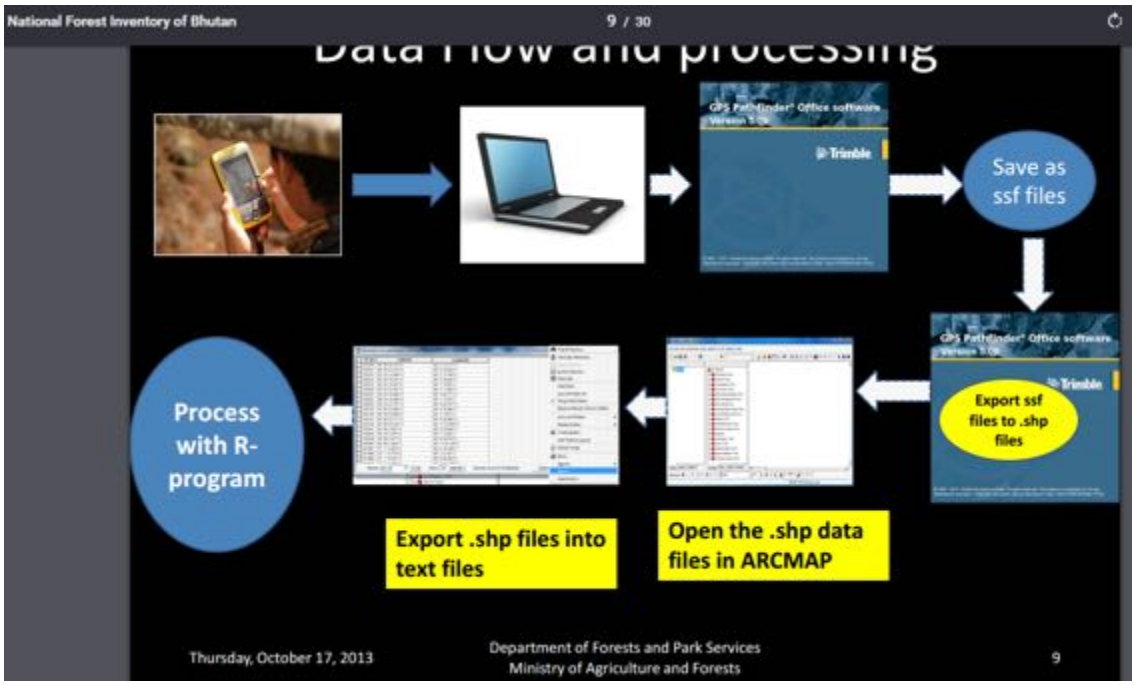
National Forest Inventory of Bhutan
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Data Flow and processing
Save as ssf files
Export ssf files to .shp files
Open the .shp data files in ARCMAP
Export .shp files into text files
Process with R-program
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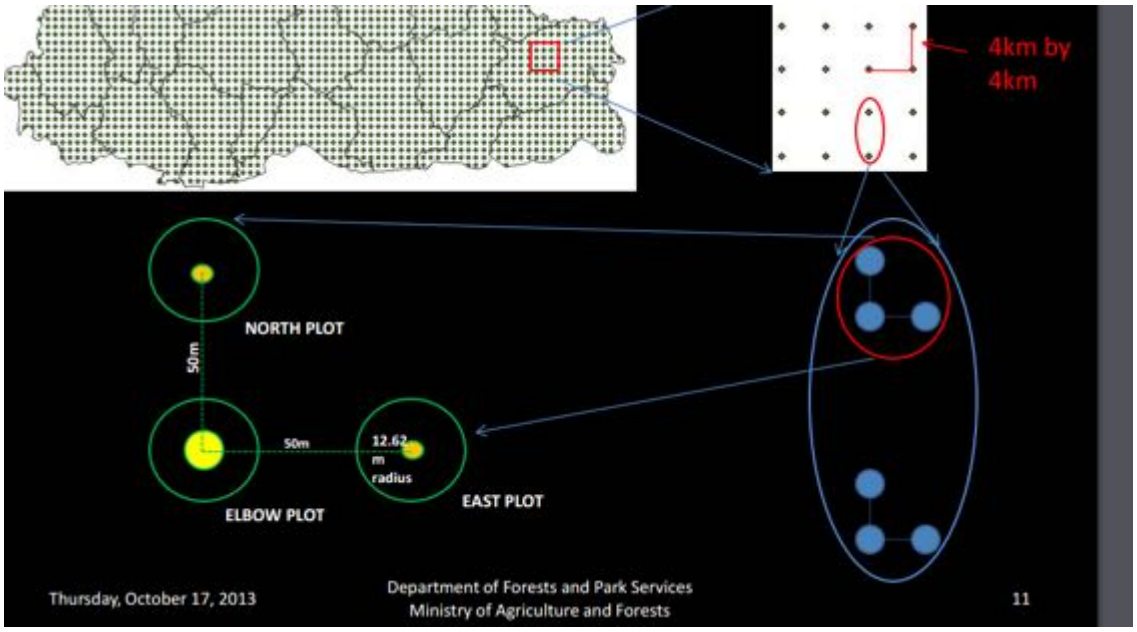
Plot design


4km by
4km
NORTH PLOT
50m
50m
12.62
m
radius
ELBOW PLOT
EAST PLOT
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We covered Bhutan with plot clusters on a 4km square grid.

Each plot cluster was located by the centerpoint of its elbow plot (L), and one to the north (N) and one to the east (E), each 50m distant from the centerplot. All three subplots were circular and were 1/20th ha in area.

Nested within the L plot was a 1/250ha plot to assess regeneration, and there were $1m^2$ circular plots nested within the other two to assess herbs. Regenerating trees were stipulated to be trees with dbh $<$ 5cm and at least 2 m tall, those that are less tahn 2 m but more than 1 year old, and recruits. Separate counts were made for all three categories of regenerating plants and trees.

The 50m transects connecting the plots were used to perform LIS for CWD.

Each plot cluster had a unique number, which was entered onto tally form. Also date, weather, altitude, crew leader name, Gewog (town), dzongkhag (province).

Also, topographic position of each subplot (ridge top, upper hill side, middle hill side, lower hill side, flat, river bed, river bank, gorge/ravine.

Also aspect, degree of slope, average height of 5 tallest trees, canopy cover percent as measured by Crown Denistometer at 10 positions on subplot.

Also ownership (Government Reserve Forest, GRF Protected Area, GRF Forest Management Unit, GRF-leased, Private, thromde, do not know).

Land cover classification:

coniferous forest
broadleaf forest
coniferous plantation
broadleaf plantation
scrub forest

meadow
chuzing
kamzhing
mixed agriculture
apple orchard
citrus orchard
areca nut
cardamom plantation
other horticulture

urban
rural
industrial
impervious surface
snow/glacier
rocky outcrop
scree
lake
reservoir
marshy area
landslide gully
ravine
other

Each had a numeric code from 1 to 28.

Vegetation composition according to types prepared for FMUs.

Forest type classification as per the Flora of Bhutan code.

Forest stand structure (open, stand initiation, stand exclusion, stand reinitiation, old growth).

Main understory type (moss, grass, herbs, bamboos, shrubs, other).

Understory percent (none, < 2%, 2-5%, 10-40%, >40%).

Non Wood Forest Produce (NWFP "will refer to only the living plant species whose plant parts – flowers, seeds, bulbs, roots, fruit, leaves, bark, any other vegetative part, or the whole plant – or its produce such as resin, katha, kutch had medicinal properties or is edible or has some utility to people as tangible goods, or has economic value. NWFP may include trees, shrubs, herbs, bamboos, grasses, creepers, reeds, orchids, canes and fungi.")

Cover percent of NWFP.

Bamboo: Yes, or No

Bamboo scientific name from drop down list; cover percent; regeneration.

Cane cover percent, and dbh.

Daphne cover category.

Snag (dead standing tree) –1-5, 5-10, > 10, none.

Fallen trees – same categories as for snags.

Beneath the Disturbance heading:

Forest fire extent (heavy moderate, light, none)

Forst fire type (underground, surface, crown, not sure/not known, not applicable)

Grazing evidence (Yes, No, Unsure)

Grazing extent (slight, moderate, severe, none)

Timber extraction (clear felling, selective felling, group felling, other, none)

Mining (yes, no, none)

Transmission lines or poles: yes, no

Garbage (food wrappers, construction waste, biodegradable waste, all, none)

Under the Forest Health heading:

Mistle toe: yes, no

Dieback fir: on or within 25 m of the plot (yes or no)

Bark beetle: yes, no

Other pests or diseases.

Under Litter, Humus, and Fuel Bed heading:

Litter depth: measure depth to nearest cm.x at three random points.

Humus depth: same as for litter

Fuel bed depth: accumulated mass of dead, woody material on the surface of the forest floor.

Litter cover percent

Bare soil percent.

Under the Soil heading:

Stoniness: none, > 10%, 10-20%, 20-30%, 30-60%, >60%

Soil drainage (poor, moderate, well drained)

Top soil moisture (dry, slightly moist, moist, wet, waterlogged)

Top soil cover (dark, reddish, yellowish, other)

Top soil color cart using the Munsell Soil chart

Top soil texture: sand, sandy loam, loam, silty loam, silt, clay loam, clay – assessed with the Rough guide in Appendix of Field Manual

Gully evidence: yes, no

Erosion evidence: yes, no

Under the Water Bodies heading:

Stream or river on plot or within 25m: yes, no

Wetland or marshy area: same as above

Lakes: same as above

Glacier: yes, no

Under the Site Value heading:

Natural trail facility (footpath, road) on or within 25m of plot (yes, no)

Scenic (yes, no)

Visitor evidence: yes (local), yes (foreigner), yes (religious) none evident, unsure

Site value: yes (cultural), yes (historical), yes (religious), none, unsure

Site name: if site has a name.

Under the Tree Data heading

Scientific name (closen from drop down list)

Common name (with note as to the dialect the name is from... Dzongkha, Tshanghe Kha, Lotsham, Bumthangp, Khenga, Trongsap, Kurtoep

Distance from plot center: preferably with laser hypsometer, with tape as backup when hypsometer cannot be used.

Azimuth: measured from North

dbh (cm.x)

Height of tree to nearest m from uphill side of tree.

Bole height: from ground to first crown-forming living or dead branch. (hypsometer to nearest m)

Crown length: hypsometer to nearest m

Crown position: dominant, dominated, suppressed, solitary

Condition of tree: healthy, diseased, abnormal and damaged, dead

Bark thickness at bh: measured with bark gauge

Core taken: yes, no

Core 1N: number of rings in Core 1

Core 1nn: number of rings in inner 5.08cm

Core 1L: length of core (in cm, or inches?)

10 year increment from Core 1, cm (cm.x?)

5 year increment from Core 1, cm

Analogous measurement from Core 2, perpendicular to Core 1.

Under the Sapling Data heading:

Scientific name.

Common name.

Number of saplings of each species

Predominant height of saplings (m)

Cover percent within subplot

Under the Shrub Data heading:

Condition: dead, alive

Scientifc name

Common name

Layer height (m)

Cover percent

Under the Herb Data heading:

Scientific name

Common/local name

Layer height

Cover percent

Number of individuals

Remards from Crew Leader

Under the Wildlife Data heading:

Mammal number: sequence number of sighting: 0, 1, 2, ...

Mammal sighted: name from dropdown list

Species identity: certain, doubtful, not relevant

Evidence type: 13 categories such as direct sighting, sounds/calls, dung/pellets/scat, skeleton, and so on

Gender: M, F, unknown

Group size: number of individuals

Remarks from crew leader

Under Bird Data heading:

Same as for Mammals

Under Reptile data heading:

Same as for Mammals

Coarse Woody Debris

Collected along 50m transect connecting N plot to L plot, and connecting E plot to L plot.

If piece is at least 1m long, and has minimum diameter of at least 10cm.

This is shown in diagram of field protocal book.

But the bad practice of requiring 10cm diameter at point if intersection is also articulated. I do not know which rule was followed.

Scientific name, large end diameter, small end diameter, diameter at intersection, length of intersection, CWD length CWD width.

Chapter 4 of Field Manual deals with protocol for data management, e.g, transfer of data from Trimble GPS to laptop

There was a separate Field Guide for Aboveground Understory and Soil Carbon Assessment,