Protocol followed for establishing and monitoring the long-term transects

1. **Criteria for choosing study area:** Out of the several factors that must be considered while establishing long-term monitoring (Marthews et al. 2014), for campuses of educational institutes, it is important to have formal tie-ups with the college authorities and ensure that there will be sufficient logistical and financial support.
2. **Criteria for choosing transect areas**: In order to ensure that the turnover of vegetation that will be sampled is representative of both, recruitment (natural or human-mediated) and mortality (human-mediated or natural), three types of areas should be preferred:
   Newly planted areas or where frequency of plantations is high and hence young trees/saplings (smaller girth class) are present; 2) Where frequency of plantations is low, and mature, old trees (higher girth class) are present; 3) A mixture of both 1, 2 which also includes trees with medium girth class (Fig. 1, 2, 3).
   Distance between two transects should preferably not be less than 5 meters. There should also preferably be some easily recognizable landmarks/ objects near the transect (eg. pole, wall, road junction, sign boards, or even a peculiar well grown tree) which makes it easier to locate the transect (i-Tree User's manual, 2008).
3. **Habitat strata in campuses:**
   Common strata in educational institutes include roads, built up areas, gardens, play grounds, hills and water bodies. Using a map of the study area (and keeping the points 1,2,4 in mind), the total number of transects should be distributed equally in all parts. As far as possible, it is advised to randomise the choice of transect locations (but keeping the points 1,2,4 in mind). Transects should be used for vegetation along roads, built up areas, hills but not gardens. For gardens, a complete enumeration should be preferred wherever feasible, or quadrats of appropriate dimensions (20m x 20m at least) should be used (Magurran, 2004). This data should be analysed separately and not with the transects.

Figure 1: a row of mature trees along a campus road

Figure 2: A sample transect showing two trees of greater girth and one newly planted sapling.

Figure 3: A sample transect with all newly planted trees.

4. **Access:** Trees that are more are less in a single file, easily accessible for measurement (usually roadside trees) should be preferred, except in some cases such as those on hills and gardens within the campus.
5. **Transect dimensions:** Since the vegetation that is being targeted is primarily found along paths, roads and along other linear infrastructure within a campus, a belt transect should be preferred with length 10m and width 2m.
6. **Sample size:** The minimum number of transects to be established and monitored each year should ideally be based on species-area curve (Magurran, 2004). However, if the number is less than 30, the data might not be enough for a robust statistical analysis. The maximum number should be limited by considering available work-force and logistics.
7. **A reconnaissance survey** must be done considering all the above points to decide possible locations.
8. **Establishing transects:** First/starting tree or nearest identifying object/ landmark (eg. pole/wall) must have the transect number written with yellow oil paint (eg. T10) and an arrow showing the transect direction. The rest trees should have a yellow line/mark on one stem per individual that is to be enumerated (Fig. 2, 4).
   Length of the transect must be demarcated using a 10m long nylon rope stretched from the starting tree to 10m in the specified direction. Width must be kept 2 meters (one meter on both sides of rope).
   All transects must be marked on a GPS unit with codes like 10A, 10B that denote start and end point of transects. A user-friendly map of these transects must be prepared for future monitoring. All transects should also been given names based on prominent trees/ landmarks eg- 'IMDR Parking up'. Transect locations may also be drawn by hand for each transect along with photographs of the earlier sampling.

Figure 4: Photo depicting a transect with the first tree marked with transect code (T10) along with the transect rope visible on the ground.

Data collection:

9. **Investigators, date, plot codes:** It is extremely important to note this information.
10. **Botanical identification**: Relevant regional and local floristic literature should be followed for plant identification followed by field validation by experts, if needed. For example, we followed Ingalhalikar and Barve (2010) and Nerlekar et al. (2016) for confirming all species encountered.
11. **What groups to measure**: It is important to measure all standing vegetation in the transects, both live and dead. All plant groups including Palms, Cycads, woody Pteridophytes, Bamboos and lianas. Non-woody groups (eg. *Dracaena* spp., *Musa* spp.) may be excluded.
12. **Measuring GBH**: Girth must be measured at 1.3m above ground of all woody species with a diameter greater than 1cm (or greater than our index finger) that are present at that height. The investigators should standardise the point of measurement ideally using a stick with a mark at 1.3m height (Marthews et al. 2014), but can also standardise it according to ones height. Measurement must be done using a measuring tape (preferably this: https://www.amazon.in/Freemans-FT15-Fiberglass-Line-Measuring/dp/B010M5HKR8). It should be noted that the steel end denotes zero for the tape. Measure girth to the nearest millimetre (eg- 30.6 cm instead of 30). For trees smaller than 10cm diameter, a digital Vernier calliper (https://www.amazon.in/YUZUKI-Digital-Caliper-150mm-inch/dp/B012VRZ694?tag=googinhydr18418-21&tag=googinkenshoo-21&ascsubtag=fbe0dd64-dff9-475b-8576-bba26a8c7bf8) can also be used instead of the tape [however, note that the measurement is of diameter here instead of girth (circumference) by the tape]
    Care should be taken to identify stems of the same tree, and for such multi-stemmed trees, girth must be entered as '10.2+20+29.5+5'. If the stems are not joint at the base as observed, they should be considered different trees (ramets) (as seen frequently in the case of *Leucaena leucocephala*). For more details about measuring irregular trees and special cases, see Marthews et al. (2014)
13. **For Bamboos:** Measure a few representative stems for each girth class (say 3-4) and note down the number of stems for each such class instead of measuring each stem manually (Marthews et al. 2014). Same can be followed for dense clumps of species like *Lantana camara.*
    Note down newly planted saplings that do not reach 1.3m height above ground separately in 'remarks' column and not in 'species' column.
14. **Height**: should be noted using visual estimation or with the help of Rangefinders. If using visual estimate, it is recommended that the investigators standardize their height estimate at the beginning of each session using the transect rope. The decision of accuracy level followed for measurement depends eventually upon the questions.
15. **Photo**- Should be clicked as follows: Keep the transect rope, click a photo in the zoomed out/ wide angle standing next to/ behind the start point so as to include first tree, rope and last tree with all trees in between preferably visible (Fig. 4).

16. **Timing for re-monitoring:** After establishing, transects should be monitored before the onset of dry season (for seasonal, deciduous regions) since leaves are retained till then which helps in correct botanical identification.
17. **Data entry, management and archiving**: Data sheets should be scanned and the hard copies should be stored securely. A metadata (description about the data) abstract file must be maintained that describes each variable measured (see https://portal.lternet.edu/nis/metadataviewer?packageid=knb-lter-bes.3300.110 for example). Over time, with increasing volume of the data, it is essential to follow good management practices (see https://www.britishecologicalsociety.org/wp-content/uploads/Publ_Data-Management-Booklet.pdf for details). Once data entry and curation are complete, the data must be archived and all files should be uploaded on an institutional portal or on data portals such as GitHub (https://github.com/), Open Tree Map initiative (https://gubbilabs.github.io/tree-map/index.html), Dryad digital repository (https://datadryad.org/) with appropriate licencing. See more about data archiving in Whitlock (2011). As an example of an effective data management system for urban long-term monitoring, see the Baltimore LTER portal (http://beslter.org/dm_policy.html) and the LTER portal (https://portal.lternet.edu/nis/mapbrowse?packageid=knb-lter-bes.3300.110).

Miscellaneous Instructions:

- The entire monitoring must be completed within a maximum of 10 days to avoid temporal bias.
- After an interval of 6 months at least, the paint marking on trees must be checked and re-painted if necessary.
- The team should have at least one person that was present for the earlier enumeration.

References:

1. Ingalhalikar, S. and S. Barve (2010). *Trees of Pune -Including Palms, Conifers, Cycads& Bamboos*. Corolla Publications, Pune, 249pp.
2. Magurran, A. E. (2004). *Measuring biological diversity*. Blackwell Science Ltd, 215pp.
3. Marthews TR, Riutta T, Oliveras Menor I, Urrutia R, Moore S, Metcalfe D, Malhi Y, Phillips O, Huaraca Huasco W, Ruiz Jaén M, Girardin C, Butt N, Cain R and colleagues from the RAINFOR and GEM networks (2014). Measuring Tropical Forest Carbon Allocation and Cycling: A RAINFOR-GEM Field Manual for Intensive Census Plots (v3.0). *Manual, Global Ecosystems Monitoring network*, http://gem.tropicalforests.ox.ac.uk/.
4. Nerlekar, A. N., Lapalikar, S. A., Onkar, A. A., Laware, S. L., and Mahajan, M. C. (2016). Flora of Fergusson College campus, Pune, India: monitoring changes over half a century. *Journal of Threatened Taxa*, *8*(2), 8452-8487.
5. Whitlock, M. C. (2011). Data archiving in ecology and evolution: best practices. *Trends in Ecology & Evolution*, *26*(2), 61-65.
6. i-Tree User's manual. (2008). Tools for assessing and managing Community Forests. Software Suite v2.1. Retrieved July 24, 2018, from http://www.itreetools.org.

Fergusson College Long-term vegetation monitoring – Data sheet template

Investigators: …… Date: …… Page ----/----

Transect no & name	Species	GBH (cm)	Height (m)	Remarks
No. : **T**___ Name: _____ _____ _____	1)			
	2)			
	3)			
	4)			
	5)			
	6)			
	7)			
	8)			
	9)			
	10)			
	11)			
	12)			
	13)			
	14)			
No. : **T**___ Name: _____ _____ _____	1)			
	2)			
	3)			
	4)			
	5)			
	6)			
	7)			
	8)			
	9)			
	10)			
	11)			
	12)			
	13)			
	14)			