Evaluating Forest Ecosystem Functions/Services based on Plant Functional Traits

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Abstract

In this paper, we firstly show some examples oftrait-based approaches for plant ecological studies. We then introduce our recent research project to evaluate the effects of tree diversity loss on forest ecosystem functions and services based on plant functional traits in Japan, and finally introduce ongoing research projects about plant functional traits in Thailand.

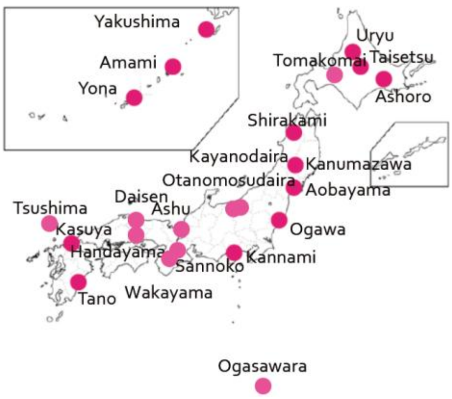
Key Word: Plant Functional traits, Ecosystem Functions/Services, Plot Data, Mapping of Ecosystem Functions/Services

Trait-based Approaches for Plant Ecology

Plant functional traits are morphorlogical, physiological, and phenological featuresthat are associated with plant ecological strategies, responses to environmental factors, and effects on other organisim and/or ecosystem functions (Perez-Harguindeguy et al., 2013). Trait-based approach is one of promising ways for understandingthe patterns and mechanisms for many ecological processes such as species interactions with abiotic/biotic factors,population dynamics, and community assembly/dynamics (Wright et al., 2004, McGill et al., 2006, Cornwell et al., 2008, Poorter et al., 2008, Ordonez et al., 2009, Katabuchi et al., 2012).For example, “leaf economic spectrum” is one of the most well known axes of plant ecological strategies, and shows the trade-offs between aquisitive and conservative ones (Wright et al. 2004). For example, aquisitive species with higher photosynthetic rate have lower leaf mass per area (LMA); on the other hand, conservative species have higher LMA, which alllows for a long leaf lifespan. Further, specific leaf area (SLA, an inverse of LMA) and wood density were shown as good predictors for juveline growth rate in five neotropical rainforests (Poorter et al, 2008). As to the plant response to abiotic environment, SLA and foliar N had significant negative relationships with soil C to N ratio(Ordonez et al., 2009), and leaf toughness showed a negative relationship with annual precipitation world-wide (Onoda et al., 2011). World-wide meta-analysis on litter decomposition rate suggested that plant species traits such as LMA and litter lignin and N concentrations predominantly control litter decomposition rate rather than climate (Cornwell et al. 2008). This strong relationship between litter decomposition and lignin content can be used for vegetation dynamic model to estimate the distribution of total litter stocks worldwide (Brovkinet al. 2012). Thesekind of studieshave stimulated researcher to construct worldwide functional traits database. TRY (http://www.try-db.org/TryWeb/Home.php) is one of the biggest plant trait database initiated in 2008, and now includes3 million trait records for about 69000 plant species contributed by 591 participants from 207 scientific institutes worldwide. TRY encourages researcher to use the trait data for their studies, and so far, 256 scientific projects have requested plant trait data from TRY. However, in this worldwide plant trait database, the contributions from Asian countries are very limited. This motivated us to construct functional trait database in Japan and Thailand for original research projects in these region.

Funtional Trait Database in Japan and Mapping of Forest Ecosystem Functions/Services

To understand how tree diversity loss affect forest ecosystem functions and services based on plant functional traits, we have constructed a trait database in Japan since 2011. To select sample species, we used tree census data of selected 1-ha plots ofMonitoring sites 1000 projectin Japan (Ministry of Environment, Japan). Monitering sites 1000 project established 55 1-ha forest plots for 44 sites throughout Japan. In those 55 plots (50 plots are natural forests, 5 plots are plantation forests), 353 species were identified. Out of 55 plots, 26 plots were selected to cover the typical forests of Japan inwide ranges of climatic and geographical gradients (Fig.1). We have colleted leaf and wood samples of three individuals for all tree species found in each 26 plots, which results in total of ca. 310 species. Sampled tree species can cover more than 95% of basal area of almost all forests in Japan.We have measured leaf and wood functional traits such aswood density, individual leaf area, LMA, leaf toughness, leaf thickness, contents of foliar nitrogen, carbon, total phenolics, condensed tannins, and lignin, etc for each samples. The ecological information such as seed mass, fruit size, maximum height, root length, etc, were also extracted from several field guides for those species. To evaluate the forest ecosystem functions or services throughout Japan, we applied this trait data to the tree census data of Forest Biodiversity Survey (Forest Agency, Japan) and to the vegetation data of National Vegetation Survey (Ministry of Environment, Japan) (Fig. 2). Forest Biodiversity Survey have been conducted since 1999, and done tree census in 0.1-ha plots at grid points of 4-km mesh throughout Japan. We used the data for 346,000 individuals of woody species from 7200 plots in forests. National Vegetation Survey has been conducted repeatedly since 1973 to elucidate vegetation changes throughout Japan. We used the vegetation data from 3rd (1983-87) and 5th-7th (1994-2009) survey to evaluate the changes of ecosystem functions and services. By using these tree census and vegetation data with our functional trait data and published climatic data (Ministry of Land, Infrastructure, Transport and Tourism, Japan), we were able to model some forest ecosystem functions and services (e.g., the potentials of photosynthetic rate or litter decomposition rate) throughout Japan and map those functions and services at nation-wide scale. From these results, we could predict how forest ecosystem functions and services respond to future human impact or climate changes.



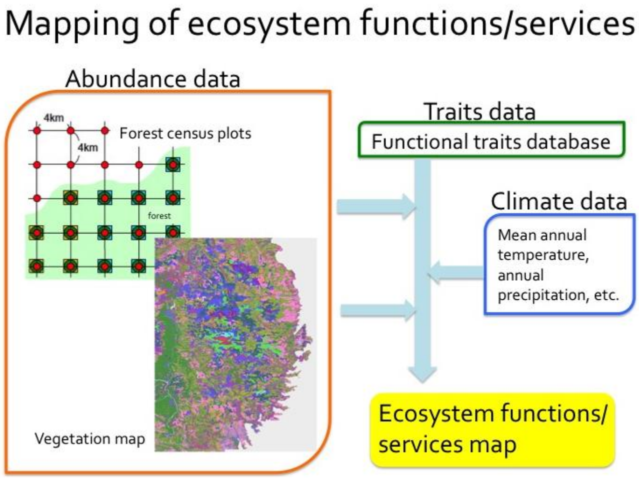


Figure 1 Distribution of plots from monitoring sites 1000 projects used for leaf and wood samples for trait measurements.

Figure 2 Procedure for mapping of ecosystem functions and services nation-wide.

Funtional Trait Database in SE Asia and Future Study in Thailand

Since 2011, we have started research projects for establising plant trait database and evaluating ecosystem functions and services in Thailand. We have already collected leaf and wood samples for ca. 1100 individuals of 363 tree species in total at the Kog Ma Experimental Watershed (Suthep-Pui National Park; 18°47’-18°50’N, 98°53’–98°55’E), the Sakaerat Environmental Research Station (14°30’N, 101°55E), and the Mae klong Watershed Research Station (14°35' N 、98°53'E) (Fig. 3). In Kog Ma, the major forest types are dry evergreen (DEF) and pine forests in lower tropical montane forests, and five 1-ha permanent plots were established in three differentforest management areas(Asanok et al. 2013). In Sakaerat, major forst types include dry deciduous forest (DDF), dry evergreen forests (DEF), and plantation forests (Doi et al. 2004), and several 1-ha plots were established. In Mae klong, major forest types include mixed deciduous forests (MDF) (Ishida et al. 2010), and a 12-ha permanent plot was established. Based on those tree census data, we have collected leaf and wood samples from tree species found in primary forests, secondary forests, pine forests and plantations to cover large basal area for those sites (Table 1.). We measured functional traits such as wood density, individual leaf area, LMA, leaf toughness, leaf thickness, contents of foliar nitrogen and carbon for those samples. We plan to analyze total phenolics, condensed tannins, and lignin for leaf samples in near future. To map forest ecosystem functions and services at nation-wide scale in Thailand, we plan to use vegetation map throughout Thailand, and apply the mean value of functional traits or calculated ecosystem functions (e.g., photosynthetic rate, GPP or litter decomposition rate) to each vegetation type. Further, by using functional traits data and tree census data in primary forests, secondary forests and plantatoins in studied sites, we plan to investigate the impact of land-use changes on functional traits, diversity and/or calculated ecosystem functions of forest ecosystems. Such kind of studies should be very useful for predicting how forest community and ecosystem functions/services respond to future human disturbance or climate changes.

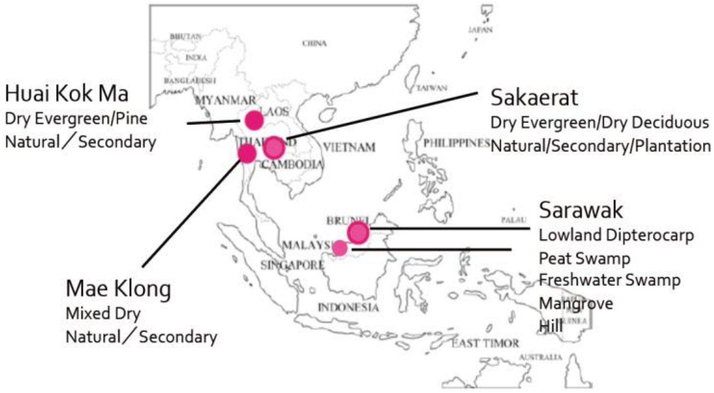


Figure 3. Distribution of sites we have already collected leaf and wood samples for trait measurements in SE Asia.

Table 1 Description for sampling site and number of sampled species for trait measurements in Thailand.

Study Site	location	AP*	MAT *	Length of dry season**	Forest type	No of sampled species
Kog Ma	18°47’N, 98°53’E	1700mm	20℃	6 months	DEF Pine	145
Sakaerat	14°26'N, 101°50'E	1260mm	26℃	6 months	DEF DDF	155
Mae Klong	14°35’N, 98°53’E	1650mm	26℃	6 months	MDF	129

*AP and MAT indicate annual precipitation and mean annual temperature, respectively. **Mean monthly rainfall is less than 100mm during dry season.

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