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Diversity of Grass (Poaceae) Flora at Nagarkot, Bhaktapur, Nepal

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Abstract
The term "flora" describes all plant life in a specific area, habitat, or time period. The main purpose of this research was to compile floral data on grasses growing along an elevational gradient in the Nagarkot forest, Bhaktapur. The highest hill in Bhaktapur, Nagarkot (1330-2175 m), offered a rare chance to examine the variety of grass along the altitude. A total of 43 species of grasses, representing 4 subfamilies, 11 tribes, 32 genera, were identified during this research. Majority of grasses, accounting for 83% of the species were terrestrial, while 11% were lithophyte, and only 6% were aquatic which is expected for the terrain. Some of the species, such as terrestrial and aquatic or terrestrial and lithophyte, have been observed to coexist. With 24 species, the lowest elevation band (1330-1610 m) has the highest diversity, while the highest band (1890-2170 m) has the lowest diversity with only 7 species.

Keywords: Altitude, Diversity, Fodder, Poaceae.

Introduction
The Poaceae or Gramineae is known as the grass family. The term "grass" is derived from the old German word "gras," which was originally used to describe grazing of livestock (Stromberg, 2011, Baum et al., 2013). According to Bews (1979), Adanson (1763), grasses are a unique group of plants that deserve the status of a family, which was named Gramineae. The type genus *Poa* served as the inspiration for the proposed name, Poaceae (Anderton & Barkworth, 2009). Grasses are common and virtually omnipresent (Simpson 2010). Grasses come in a variety of sizes, from tiny, unnoticeable herbs that are less than an inch long to enormous bamboos that can reach 130 feet in height (Rudall et al., 2005; Kellong, 2015; Gandi & Pandhya, 2016).

In Nepal, there are 121 genera and 470 species of Poaceae, according to Press et al. (2000). According to Bouchonak-Khelladi et al., (2010) and APG IV, the Poaceae (R.Br.) family is the fifth-ranked family of flowering plants worldwide. 11,506 species from 768 genera, 12

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subfamilies, 52 tribes, 5 supersubtribes, and 90 subtribes were reported worldwide in a recent genetic categorization system of grasses (Soreng et al., 2017). According to Rajbhandari and Rai, there were 416 distinct species of grass in Nepal in 2017 (Rajbhandari & Rai, 2017). In the grass family, Shrestha et al., (2018) found 130 genera and 444 species the following year (Shrestha et al., 2018). The main objective of this research is to highlight an overview and distribution of grasses of Nagarkot forest, which is also expected to contribute for the Flora of Nepal documentation. By creating an updated database of grasses, this work will advance the systematic study of grasses.

Materials and Methods

Study Area

Nagarkot, located in Bhaktapur district at an altitude of 1,330 to 2,175 meters (27.723° N, 85.524° E), is renowned for its scenic beauty and diverse flora and fauna (Sharma et al., 2000). The area experiences a warm, temperate climate with an average annual temperature of 16.6°C and receives most of its 1,800 mm of rainfall during the southwest monsoon (June to August). Rich in biodiversity, Nagarkot hosts a variety of plant species such as ferns, orchids, pine trees, rhododendrons, and more, along with fauna like barking deer, wild pigs, golden eagles, and giant squirrels, making it a popular destination for tourists and hikers (Sharma et al., 2000).

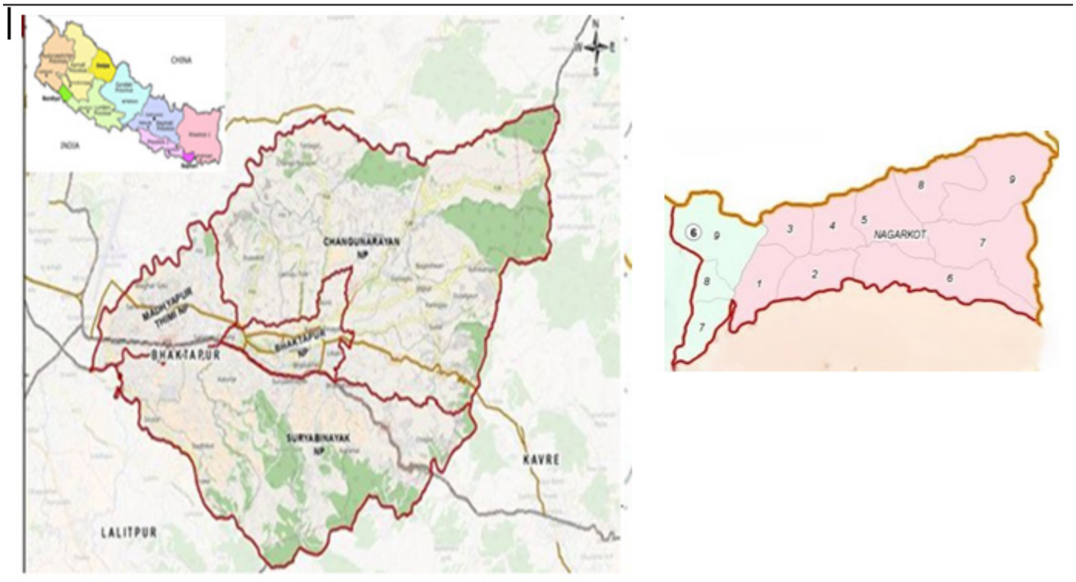

Figure 1: Map of study area, Nagarkot

Field Sampling and Plant identification

From May 2018 to January 2019, a thorough survey was conducted during several seasons to collect grass species from their natural habitats.

Before collecting the targeted grass, pictures of its habitat were taken. Using a digger, the specimen was removed with its rhizomatous root for investigation. Field data was recorded in a notebook and a jewel tag with a code number was attached to the specimen. Large grasses were trimmed into the necessary sizes without losing any significant distinctive traits before pressing. The collected specimen were then pressed into newspaper or blotting paper. The larger specimens were pressed in N or V shape. Each specimen contained a corrugated sheet for rapid drying. Tissue paper was applied to the delicate spikelets. Newspapers were then consistently replaced every day until the plants dried. The collection and processing of the specimens was done in accordance with Siwakoti and Rajbhandary's (2015) recommended standard procedure. On standard-sized herbarium sheets , the dried specimens were mounted. The dried samples were mounted, labelled with a field note.

The grass species were identified using specimens from the Catalogue of Nepalese Flowering Plants, The Handbook of Flowering Plants, Flora of the Kathmandu Valley, Flora of China, and the Flora of Bhutan. The identified specimens were again verified from experts. With the help of APG IV and GPWG II (2012), every species were then categorised.

Results

Grass diversity and distribution

Total 43 species of grass were recorded, which includes 4 subfamilies, 11 tribes, and genera. These species belong to the Arundinoideae (2), Pooideae (6), Chloridoideae (7), and Panicoideae (28) subfamilies, respectively (Figure 2). Subfamily, Panicoideae had high level of diversity which is followed by subfamily, Chloridoideae (Figure 2).

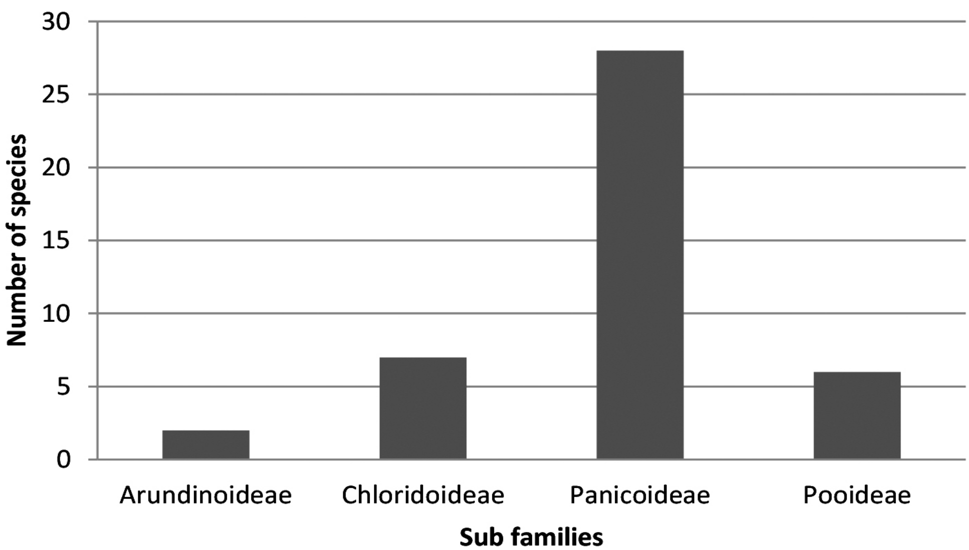

Figure 2: Sub familywise species richness

The Paniceae tribe of the Panicoideae subfamily had the highest level of diversity (14), followed by the Andropogoneae tribe (10) (Figure 3).

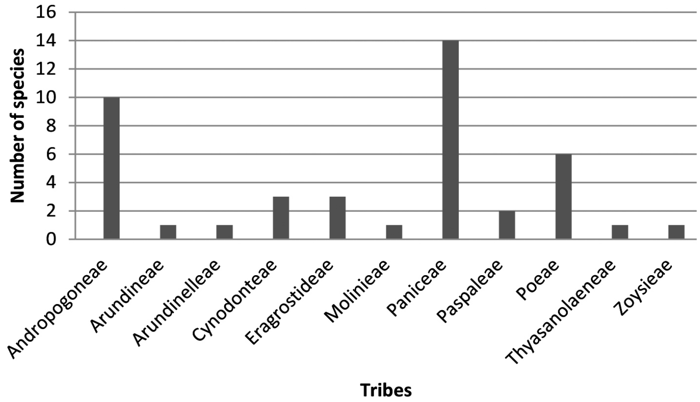

Figure 3: Total species in each tribe

Among 32 genera, E*ragrostis, had four species. Bothriochloa, Oplismenus, Echinochloa, Setaria and Digitaria* were the next largest, each having two species. The remaining genera each had one species.

Species distribution across habitats

The identification of 43 different species of grasses revealed that 83% of them were terrestrial, 11% were lithophytes, and the remaining 6% were aquatic. Land-based grasses outnumbered aquatic and litophytic plants. *Tripogon filiformis, Arthraxon lancifolius, Eragrostis amabilis, Arthraxon lancifolius and Digitaria longiflora* were the lithophytic grasses and *Coix lacryma-jobi* and *Paspalum distichum* were found growing only in water (completely aquatic). Some of the species have been found to be flourishing in habitats that are both terrestrial and aquatic or terrestrial and lithophytic (Figure 4). Generally, the prevalence of grasses in terrestrial environments can be attributed to several factors like adaptability, rapid growth, efficient photosynthesis, and resilience to disturbance (Hubbard, 1984). The distribution of terrestrial, lithophytes and aquatic grasses depends on a number of local environmental, geological, and ecological conditions (Stromberg, 2011).

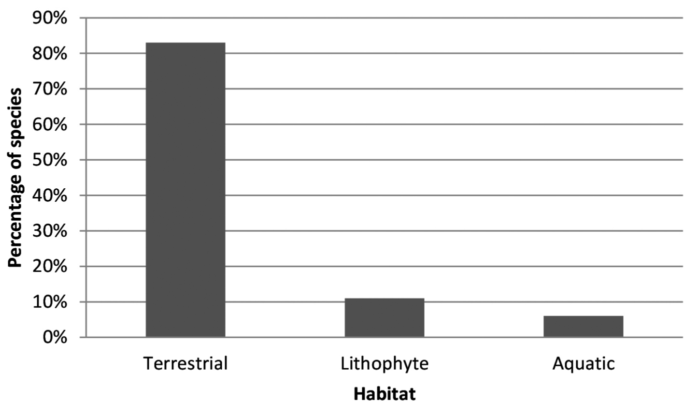

Figure 4: Proportion of species across the habitat

Distribution of species along the altitudinal gradient

The altitude of the study area ranges from 1330 - 2175 m . Out of 43 species of grass, the lowest elevation band, 1330 -1610 m, had more diversity, with 24 species, while the highest range, 1890 -2175 m, had the lowest diversity, with only 7 species. 12 species were represented in the middle band, 1580-1830 m, according to Figure 5. This study demonstrated that grasses were most abundant and diverse at elevations between 1300 and 1600 m probably due to ideal climate for grasses in terms of temperature, precipitation, soil parameters, and other factors.. However, the altitude range between 1800 and 2000 m, which includes a very moist area, had the lowest grass diversity.

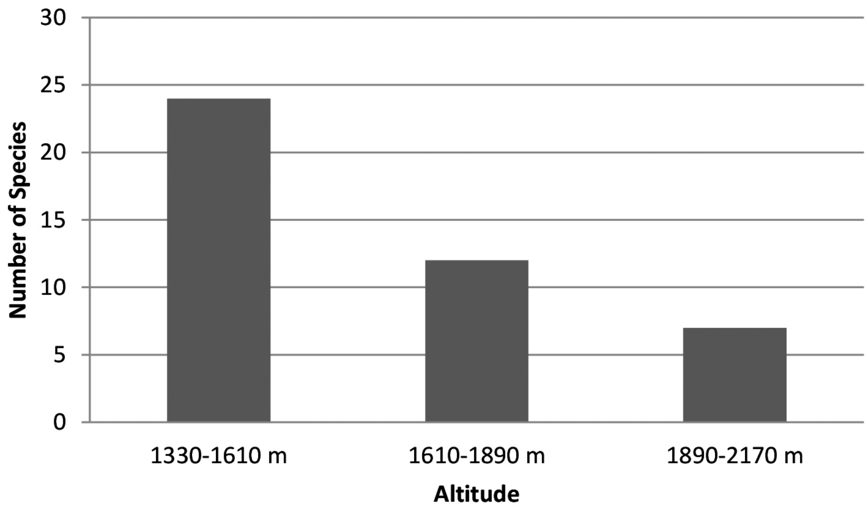

Figure 5: Total species along the altitudinal range (based on herbarium collection)

Discussion

Nagarkot spans across different ecological zones due to its varying altitudes, ranging from subtropical to temperate forests. This diversity of habitats supports a wide array of grass species adapted to different environmental conditions (Kumar, 2014). This study demonstrated that grasses were abundant and diverse in this area. The elevation gradient in this region also contributes to a rich tapestry of grasslands, each adapted to specific climatic conditions (Komer, 2000). Generally, the prevalence of grasses in terrestrial environments can be attributed to several factors like adaptability, rapid growth, efficient photosynthesis, and resilience to disturbance (Hubbard, 1984). The distribution of terrestrial, lithophytes and aquatic grasses depends on a number of local environmental, geological and ecological conditions (Stromberg, 2011). Grasses have evolved characteristics that make them well-suited to survive grazing and other forms of disturbance. They often have growing points close to the ground (like rhizomes or basal meristems) that allow them to regrow quickly after being grazed or trampled. Overall, the adaptability, rapid growth, efficient photosynthesis, and resilience to disturbance make grasses dominant in many terrestrial environments across the globe (Kumar, 2014). Rocky substratum creates a distinctive habitat that is primarily recognized for its distinctive flora and endemism (Watve, 2006 & 2010). Rocky substratum also support the growth of grasses with distinctive adaptations (Baskin & Baskin, 1988; Watve, 2010). *Tripogon filiformis, Arthraxon lancifolius, Eragrostis amabilis, Arthraxon lancifolius and Digitaria longiflora* were the lithophytic grasses. Some grasses had wide stolons that floated on water and were aquatic. *Coix lachryma-jobi* and *Paspalum distichum* were aquatic species. As the intensity of light reaching the ground is significantly influenced by canopy (Panthi et al., 2007, Vetaas, 1997, Sharma et al., 2016), the abundance of grasses are typically found in the open region, where sunlight is most accessible and there is a dearth of organic nutrients. One of the potential reasons for the lower distribution of grasses in the core forest could be the extremely dense and high tree canopy cover of the Nagarkot forest.

In the current study, the lowest belt contained the greatest variety of grass species. In moist and shaddy areas, the pattern of grass distribution was less pronounced (Hubbard, 1984). In this region, grasses were more prevalent along the road than in the main forest. Typically, grasses are widely found in open canopy areas where amount of sunlight is greatest and organic nutrient levels are lowest (Rahbek, 1997: Kumar, 2014). Along the altitudinal gradient, there were decreasing trends in the species richness of grasses (Figure 5). According to the general theory regarding pattern of species richness and elevation, species richness gradually decreases as elevation rises (Brown & Lomolino, 1998: Korner, 2000: Fossa, 2004,: Baniya et al., 2010). In summary, the combination of favorable climate conditions, moisture availability, competitive advantage, human activities, fire adaptations, and soil characteristics contributes to the abundance of grasses in lower elevations or belts of terrestrial environments.

Conclusion

The current study has documented 43 species of grasses that are divided into 4 subfamilies, 11 tribes, and 32 genera. The abundance of grasses in Nagarkot reflects the region's ecological richness and highlights the importance of conserving these unique ecosystems. This work provides a baseline in grass taxonomy of Bhaktapur district. Further research into the dynamics of these grasslands and their response to environmental changes can inform conservation strategies aimed at preserving Nagarkot's natural heritage.

Acknowledgements

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References

Anderton, L. K. and Barkworth, M. E. (2009). Grasses of the Intermountain Region. *Intermountain Herbarium*, Utah State University, Logan, Utah .

Angiosperm Phylogeny Group IV (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: *Botanical Journal of the Linnean Society*, 181: 1-20.

Baniya, C. B., Solhoy T., Gauslaa, Y. and Palmer, M. W. (2010). The elevation gradient of lichen species richness in Nepal. *The lichenologist*, 42: 83-96.

Baskin, J. M. and Baskin, C. C. (1988). Endemism in Rock Outcrop Plant Communities of Unglaciated Eastern United States: An Evaluation of the Roles of the Edaphic, Genetic and Light Factors. *Biogeography*, 15: 829-840.

Baum, B. R., Edwards, T. and Johnson, D. A. (2013). What does the 5S rRNA multigene family tell us about the origin of the annual Triticeae (Poaceae)? *Genome*, 56(5): 245-266.

Bews, J. W. (1979). T*he World's Grasses: Their Differentiation, Distribution, Economics and Ecology*. Longmans, Green and Co. London, New York.

Bouchenak-Khelladi, Y., Verboom, G.A., Savolainen, V. and Hodkinson, T. R.(2010). Biogeography of the grasses (Poaceae): a phylogenetic approach to reveal evolutionary history in geographical space and geological time. *Botanical Journal of the Linnean Society*, 162: 543-557.

Brown, J. H. and Lomolino, V. R (1998). *Biogeography.Sinauer. Sunderland*, MA. Pp. 1-24.

Fosaa A. M. (2004). Biodiversity pattern of vascular plant species in mountain vegetation in the Faroe Islands. *Diversity and Distributions*,10: 217-223.

Gandi, D., Albert, S. and Pandhya, N. (2016). *Hand book on the Morphology of Common Grasses: Identification and Characterization of Caryopsis and Seedling*. Apple Academic Press, Gujrat, India.

Grass Phylogeny Working Group I. (2001). Phylogeny and subfamilial classification of the grasses (Poaceae). *Annals of the Missouri Botanical Garden*, 88: 373-457.

Grass Phylogeny Working Group II. (2012). New grass phylogeny resolves deep evolutionary relationships and discovers C_4 origins. *New Phytologist*, 193: 304–312

Hubbard, C. E. (1984). *Grasses*. 3rd ed., Harmondsworth: Penguin Books.

Kellogg, A. E. (2015). *The Families and Genera of Vascular.Monocots-Poaceae*.Volume XIII. Springer International Publishing, Switzerland.

Korner, C. (2000). Why are there global gradients in species richness? Mountains might hold the answer. *Trends in Ecology and Evolution*, 15: 513-514.

Kumar, A. (2014). *Exploration and Systematic of the Grass Flora of Panjab*. Phd thesis, Guru Nanak Dev University, Amritsar, India.

Panthi, M. P, Chaudhary, R. P. and Vetaas, O. R. (2007). Plant species richness and composition in a trans-Himalayan inner valley of Manang district, Central Nepal. *Himalayan Journal of Sciences*, 4(6): 57-64.

Press, J. R., Shrestha, K. K. and Sutton, D. A. (2010). *Annotated Checklist of the Flowering plants of Nepal*. The Natural History Museum, London.

Rahbek, C. (1997). The relationship among area, elevation, and regional species richness in Neotropical birds. *American Naturalist*, 149: 875-902.

Rajbhandari, K. R and Baral, S. R. (2010). New records of grasses for Nepal. *Bul. Dept. Pl. Res*. No.32: 1-2

Rajbhandari, K. R. and Rai, S. K. (2017). *A Handbook of the Flowering Plants of Nepal*.Volume I. Department of Plant Resources.Thapathali, Kathmandu, Nepal.

Sharma, U. K., Kajii, Y., & Akimoto, H. (2000). Characterization of NMHCs in downtown urban center Kathmandu and rural site Nagarkot in Nepal. *Atmospheric Environment*, 34(20), 3297-3307.

Shrestha, K. K., Bhattarai, S. and Bhandari, P. (2018). *Handbook of Flowering Plants of Nepal*. Scientific Publishers India, Jodhpur.

Simpson, G. M. (2010). *Plant Systematics*. Elsevier Academic Press, London, UK. pp. 266-275.

Siwakoti, M. and Rajbhandary, S. (2015). *Taxonomic Tools and Flora Writing*. Department of Plant Resources, Ministry of Forests and Soil Conservation and Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Soreng, J. R., Paul, Peterson, P. M., Romaschenko, K., Davidse, G., Teisher, J. K., Clark, L. G., Barbera, P. Gillespie, L. J. and Zuloaga, O. (2017). A worldwide phylogenetic classification of the Poaceae (Gramineae) II: An update and a comparison of two 2015 classifications. *Journal of Systematics and Evolution*, 55(4): 323-365.

Stromberg, C. A. E. (2011). Evolution of grasses and grassland ecosystems. *Annual Review of Earth and Planetary Sciences*, 39: 517-544.

Vetaas, O. R. (1997). The effect of canopy disturbance on species richness in a central Himalayan Oak forest. *Plant Ecology*,132: 29-38.

Watve, A. (2006). *Ecological studies of Lateritic Plateau habitats in Northern Western Ghats*. New Delhi, India.

Watve, A. (2010). *Rocky plateaus (Northern Western Ghats and Konkan)*. New Delhi, India.

Appendix

Table I: List of grasses collected from Nagarkot

Code No.	Scientific name	Altitude (m)	Latitude (°)	Longitude (°)	Habitat	Date of collection
NB 51	*Agrostis micrantha* Steud.	1876	27.344	85.231	Terrestrial	9th Sep, 2018
NB 21	*Arthraxon lancifolius* (Trin.) Hochst	1590	27.324	85.35	Lithophyte	2nd Oct, 2018
NB 18	*Arundinella nepalensis* Trin.	1560-2100	27.345	85.224	Terrestrial	31st Aug, 2018
NB 29	*Arundo donax* L.	2168	27.344	85.234	Terrestrial	2nd Oct, 2018
NB 42	*Avena fatua* L.	1500	27.344	85.224	Terrestrial	9th Sep, 2018
NB 38	*Axonopus compressus* (Sw.) P. Beauv.	1550	27.432	85.382	Lithophyte	31st Sep, 2018
NB 07	*Bothriochloa pertusa* (L.) A. Camus	1434	27.436	85.329	Terrestrial	1st Jan, 2019
NB 60	*Brachiaria villosa* (Lam.) A. Camus	1575	27.356	85.333	Terrestrial	31st Aug, 2018
NB 10	*Capillipedium assimile* (Steud.) A. Camus.	1400-2100	27.344	85.234	Terrestrial	9th Sep, 2018
NB 90	*Coix lacryma jobi* L.	1400	27.432	85.382	Aquatic	27th Jan, 2019
NB O3	*Cynodon dactylon* (L.) Pers.	1550	27.432	85.382	Terrestrial	31st Aug, 2018
NB 54	*Cyrtococcum patens* (L.) A. Camus	1500	27.432	85.382	Terrestrial & Aquatic	31st Sep, 2018
NB 67	*Digitaria ciliaris* (Retz.) Koel.	1578	27.432	85.382	Terrestrial	31st Sep, 2018
NB 75	*Digitaria longiflora* (Retz.) Pers.	1976	27.345	85.231	Lithophytes	27th May,2018
NB 09	*Echinochloa colona* (L.) Link.	1590	27.345	85.224	Terrestrial	31st Sep, 2018
NB 67	*Echinochloa crusgalli* (L.) P. Beauv.	1700	27.432	85.382	Terrestrial	5th Sep, 2018
NB 16	*Eleusine indica* (L.) Gaertn.	1550-1600	27.35	85.224	Terrestrial	31st Aug, 2018
NB 49	*Eragrostis amabilis* (Kunth) Steud.	1500	27.345	85.382	Lithophyte	31st Aug, 2018
NB 15	*Eragrostis atrovirens* (Desf.) Trin. ex. Steud.	1550	27.432	85.382	Lithophytes	27th Jan, 2019
NB 40	*Eragrostis nigra* Nees ex. Steud.	1550-2100	27.467	85.367	Terrestrial	27th Aug, 2018
NB 50	*Eragrostis pilosa* (L.) P. Beauv.	1550	27.432	85.382	Terrestrial	31st Aug, 2018

NB 43	*Impereta cylindrica* (L.) Rausch.	1800	27.345	85.232	Terrestrial / Lithophyte	31st Aug, 2018
NB 28	*Microstegium ciliatum* (Trin) A. Camus	1890	27.343	85.224	Terrestrial	2nd Sep, 2018
NB 26	*Mischanthus nepalensis* (Trin.) Hack.	1390	27.344	85.234	Terrestrial/ Lithophyte	5th Sep, 2018
NB O1	*Oplismenus burmanni* (Retz.) P. Beauv.	1300	27.432	85.382	Terrestrial/ Lithophyte	2nd Sep, 2018
NB 45	*Oplismenus compositus* (L.) P. Beauv.	1790	27.344	85.224	Terrestrial	27th May, 2018
NB 41	*Panicum humile* Nees ex.Steud.	1550	27.432	85.382	Terrestrial	31st Sep, 2018
NB 14	*Paspalum distichum* L.	1550	27.432	85.382	Aquatic	1st Aug, 2018
NB 02	*Paspalum scrobiculatum* L.	2023	27.345	85.232	Terrestrial	1st Aug, 2018
NB 47	*Pennisetum purpureum* Schumach.	1550	27.432	85.382	Terrestrial	2nd Sep, 2018
NB 20	*Phalaris minor* Retz.	1985	27.345	85.231	Terrestrial	9th Sep, 2018
NB 35	*Phragmites karka* (Retz.) Trin. ex. Steud.	1579	27.343	85.235	Terrestrial	2nd Sep, 2018
NB 25	*Poa annua* L.	1500-2100	27.432	85.235	Terrestrial & Aquatic	27th May, 2018
NB 11	*Polypogon monspeliensis* (L.) Desf.	1589	27.342	85.242	Terrestrial & Aquatic	1st Aug, 2018
NB 68	*Saccharum rufipilum* Steud.	1800	27.342	85.234	Terrestrial/ Lithophyte	5th Sep, 2018
NB 24	*Saccharum spontaneum* L.	1456	27.234	85.382	Terrestrial	5th Sep, 2018
NB 19	*Sacciolepis indica* (L.) Chase	1556	27.234	85.345	Terrestrial	9th Sep, 2018
NB 12	*Setaria parviflora* (Poir.) Kerg.	1900	27.344	85.232	Terrestrial	2nd Sep, 2018
NB 48	*Setaria plicata*(Lam.) T. Cooke.	1890	27.344	85.232	Terrestrial	2nd Sep, 2018
NB 31	*Sporobolus fertilis*(Steud.) Clayton	1487	27.344	85.234	Terrestrial	1st Aug, 2018
NB 37	*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda	1567	27.344	85.234	Terrestrial	5th Sep, 2018
NB 30	*Tripogon filiformis* Nees ex. Steud.	1550-1850	27.234	85.333	Lithophyte	5th Sep, 2018