# Guidelines for Phenology Observation

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## Acronyms and abbreviations

| | |
|---|---|
| HEROES | Himalayan Environmental Rhythm Observation and Evaluation System |
| USAPN | USA National Phenology Network |
| USA | United State of America |
| IPCC | Intergovernmental Panel on Climate Change |
| UWICE | Ugyen Wangchuck Institute for Conservation and Environment |
| BPN | Bhutan Phenology Network |

## Introduction

Phenology is the study of recurring plant and animal life cycle stages, specifically known as phenophase. Phenophase is an event in life cycle of plants or animals with specific starting and ending time. It is a budburst, leafing, flowering, fruiting, emergence of insects, migration of birds, hibernation of animals, etc. More simplistically, as per USA National Phenology Network (USAPN), phenology is defined as nature's calendar. It can be observed at a small scale such as observing a peach plant in your backyard garden to regional and global scale observation using satellite image.

Phenology has varied applications. Since ancient times, phenology has been used to determine the best time for planting and harvesting the agricultural crops: for determining the best time for harvesting wild honeybee: for determining the best time for hunting wild animals. In Bhutan, for example, phenology is being used for determining the arrival of spring season, which indicates an onset of farming activities.

Recently, phenology is used as a tool to study the impact of climate change on biodiversity, agricultural practices, etc. Also, phenology has been used in ecotourism to determine the best time for organising nature tour and in health sector, to forecast the pollen allergy.

## Phenology and climate change

Phenological event is influenced by climate. Climate is determined by average long-term observation of weather parameters such as temperature, precipitation, solar radiation, etc. Events like flowering and bird migration are known to be the most sensitive biological response to climate change. Therefore, knowing how plants and animals respond to climate change can help us to predict whether their population will grow or shrink- making phenology leading indicator of climate impact.

Globally, earlier spring and late autumn events are recorded by leading scientists and naturalistic. Intergovernmental Panel on Climate Change (IPCC), for examples, has found that the spring onset has been advancing at a rate of between 2.3 and 5.2 days per decade since 1970's. IPCC concluded that phenology "is perhaps the simplest process to track changes in the ecology of species in response to climate change".

Consequently, such changes manifest as species range shift, changes in species phenological schedules, etc. But not all the species respond equally to these changes, leading to mismatch in species life cycle events. This could alter the existing interactions and processes among species. As a result, this could have serious implications on our biodiversity and environment.

## About HEROES

HEROES stands for Himalayan Environmental Rhythms Observation and Evaluation System". When all evidences around the globe indicates changes in floral and faunal life cycle due to climate change, changes must be happing in Bhutan as well. However, as of now, we don't have any record to say how and to what extent it has changed. We don't have any baseline data to compare the phenological event and say that it has changed over time. There is huge data gap in what we have and what we need to have to really

understand the impact of climate change on our biodiversity and its societal implications.

**HEROES**, as a monitoring system, will bridge this data gap. In addition, as a citizen science initiative, it will immensely contribute in enhancing awareness of citizen on climate change and its impact. Above all, the data collected from the project would help scientists, researchers and managers to identify species which are changing and if so, how. Ultimately, this can contribute in better prediction on impact of change to phenological pattern of natural systems.

## Observation Guidelines:

All phenology observations have one simple goal: to obtain a precise date of key lifecycle events. Given the diverse group of observers and variation in how each plant species completes a given phenophase, it is very important to have standard observation protocols or guidelines. Also, it is very important to have uniform data to facilitate comparative analysis of observed changes with time.

This guideline or observation protocols incorporate all basic steps, beginning from site selection to submission of observed data. Altogether, we have listed five general steps necessary for initiating phenology observation project (refer **Figure 1**). This is particularly important when we have diverse observers, beginning from lower grade schools to high schools. Regardless of nature of observation (single plant or patch), observers are recommended to follow the steps as summarized below:

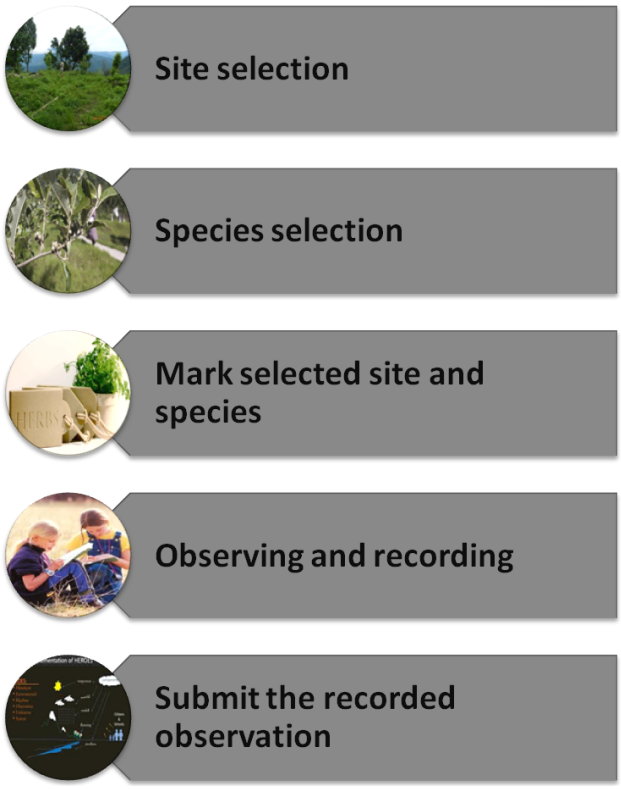



Figure 1: General steps for phenology observation and recording

## How to select the monitoring site

Selection of the site is usually determined by following criteria:

### *Types:*

Depending on the types of species, a site could be patch or single plant. If you want to monitor plant species like herbs, which is difficult to observe as an individual plant, choose patch as a monitoring site. However, if you want to monitor tree and shrub species that exist singly, you can monitor it as a single plant. For example, if you want to monitor the flowering pattern of strawberry, your monitoring site should be a patch of an appropriate size. It can't be single strawberry plant.

### *Representation:*

Whether you choose single plant or plot, your site should always represent the local environment of that place. Site with extreme or deviation from normal site conditions should be avoided. If the species are located in forested area, the selected site should be similar to nearby forest. For example, if the site is located in heavily irrigated area or highly modified area, the site may not represent the local condition of that area.

### *Replication:*

If you are observing individual species more than at one site, make sure they are not direct neighbours. However, they should be located in the similar site condition. For example if two similar species is located at two different site conditions (open and forested area), they may exhibit phenophase pattern at different time scale likely to be driven by the site characteristics.

### *Convenience:*

It is very important to keep all observation sites at a convenient distance so that you can visit the site regularly to monitor the plants. Your choice for monitoring distance should be determined by time availability and frequency of observation you are willing to take. For more intensive observations, it is always better to have site that is close to your work area. However, if schools don't have recommended plant species within the school campus, the selection of site outside school campus has to be considered but within the walking distance.

## How to select the plant species

Selection of species for phenology is usually determined by criteria such as objectives for observation, vegetation zone, phenophase, species distribution range and an ease of species identification.

### *Objectives:*

The selection of species for phenology observation depends on the objectives for observation. For example, if observation is for agricultural purpose, crops such as rice, wheat, and maize can be selected. However, if observation is to monitor forest tree species, forest trees such as fir, rhododendron, etc can be selected. Since our objective is to record the changes in phonological events, likely due to climate change and environment variation, a mixed of forest and horticultural plant species is recommended.

### *Vegetation zone:*

An availability of species for phenology monitoring depends on vegetation types. In the broadleaved forest, species such as oak, walnut, birch, etc are found. In alpine forest, rhododendron, blue poppy, primrose, etc are found. So, besides objectives, the selection of plant species for phenology monitoring depends on vegetation zone present in that particular area.

### *Phenophase:*

Species selected for phenology should have easily identifiable and distinct phenophase: leaf bud burst, leaf sprouting, flower bud, and open flowers. If the phenophase is not distinct, it will be very difficult to observe and recognize changes in the phenophase. It is very important to define exactly the phases that are to be observed. Also, it is very crucial to note that there are lots of variations in way and order that each species display the phenophase. For example, evergreen plant will not shed all their leaves, whereas broadleaved plants do. So, in case of evergreen, leaf shedding phenophase timing is not that distinct, and can't be recorded easily.

### *Species distribution:*

Species with wide distribution ranges are normally given more preferences. They are known to facilitate comparison of phenophase timing for specific plant across altitudinal gradient. Therefore, species with wide distribution range are considered as calibration species. An inclusion of at least few calibration plants species are recommended in each school.

### *Identification:*

When selecting plant for phenology observation, plant should be well known and easily identifiable. Usually identification should be done prior to observation.

## How to mark the selected plant species

Since the plant species selected for phenology observation need to be visited regularly and observed, it should be distinctively marked. An individual plant should be labeled with scientific name, common name and plant identity as shown:

Botanical name: *Prunus persica*
Common name: Peach
Plant ID : jhsbpp

Figure 2: Label

However, for patch, the patch boundary needs to be marked with distinctive flag at four corners of an area. For tree, shrub and herbs, wooden plank of appropriate size is recommended to be used as a label (**Figure 2**).

## What to observe

The success of phonological study depends on two things: consistent observation and accurate identification of phenophase. Phenophase observation is made much easier if we take note of certain features such as:

1) Floral architecture or inflorescence type: Are flowers clustered in inflorescence or are they borne singly?
2) Habit: Is the plant herb, shrub or tree?

Before recording the phenophase, it is very important to determine flowering architecture of the plant that you are observing (refer **Appendix I**). Also, based on the growth form, determine habit of your plant that you are observing (refer **Appendix II**). Habit types and flowering patterns will have a strong effect on how you record the phenophase of the plant.

It is very important to know how phenophase of plants differ in terms of how and when it occurs. For examples, in *Bombax ceiba*, flowering occurs before leaf sprouting. Likewise, evergreen plants don't drop all their leaves in the autumn and winter season. Although there is considerable variation in how and when each species exhibit different phenophase stages, the generalized plant phenological sequences can be summarized as follows (**Figure 3**).

Figure 3 : General phenophase sequence

**Leaf bud burst:** Leaf bud burst is stage when leaf tip is visible at the end of bud, but before first leaf has unfolded to expose leaf petiole or leaf base (**Figure 4**).

*Prunus persica* *Bombax ceiba* *Juglans regia* *Quercus grifithii*

**Figure 4: Lead bud burst of different plant species**

**Young leaf:** Young and unfolded leaf is stage when its entire length has emerged from bud scale so its leaf stalk or petiole is visible at its point of attachment to stem, but before leaf has reached its full length or turn dark green or mature(**Figure 5**).

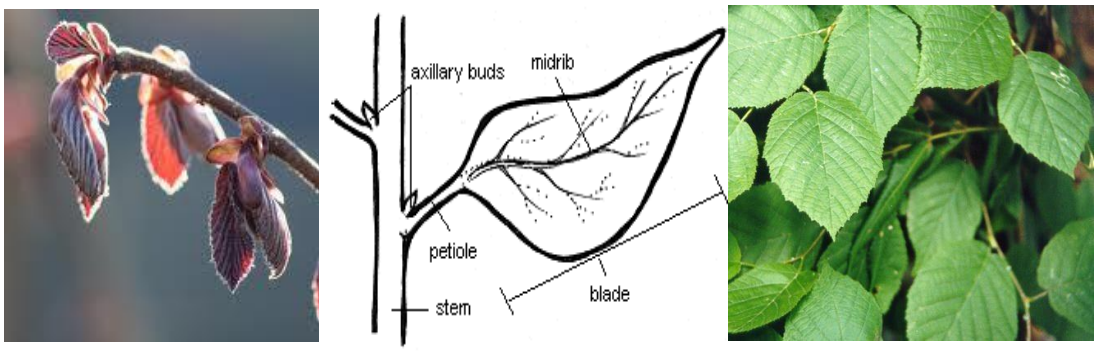



**Figure 5: Young leaf (point of attachment of petiole to stem visible)**

**Flower bud:** Flower bud is a stage when one or more, fresh opened or unopened flower is visible on the plant, but before all flowers parts separate from each other revealing inner reproductive parts such as stamen and pistil (refer **Appendix II**). If flower is clustered as inflorescence, phenophase observation should be made for each individual flower in the inflorescence (**Figure 6**).

*Prunus persica* *Bombax ceiba* *Juglans regia* *Quercus grifithii* *Erythrina stricta*

**Figure 6: Flower bud of different tree species**

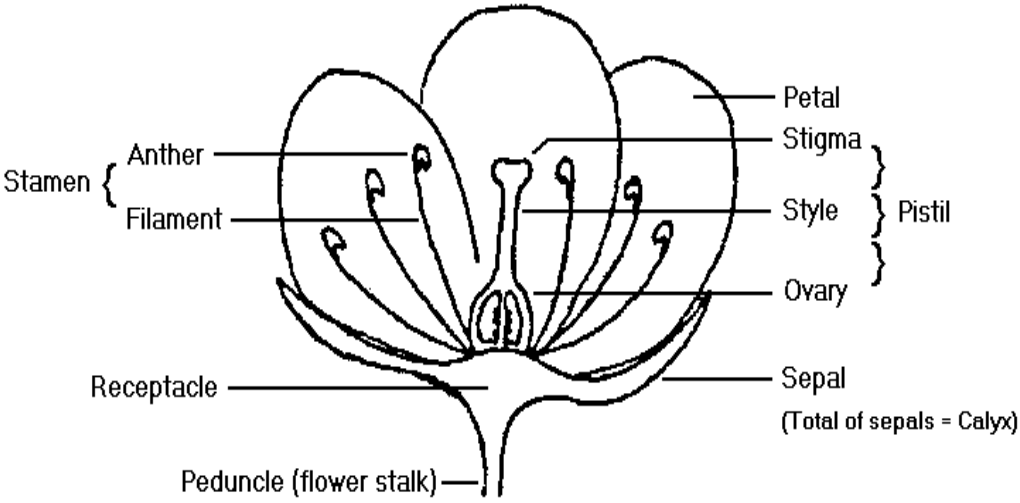



Figure 7: Flower structure

**Open flower:** Open flower is a stage when reproductive parts are visible between or within other floral parts (sepals and petals) or outer floral parts have separated revealing stamen and pistil (refer **Figure 7**). If the plant has inflorescence, observe each flower of the inflorescence. An opening of any single flower of the inflorescence can be considered as open flower (**Figure 8**).

*Prunus persica* *Bombax ceiba* *Juglans regia* *Quercus grifithii* *Erythrina stricta*

Figure 8: Open flower of different plant species

**Young fruit:** Fruit is considered as reproductive stage when it has not attained full maturity or reached full size, but before it has changed color on maturity or readily drops from tree (**Figure 9**).

*Prunus persica* *Bombax ceiba* *Juglans regia* *Quercus grifithii* *Erythrina stricta*

Figure 9 : Young fruit of different plant species

**Ripe fruit:** Ripe fruit is reproductive stage when it has attained maximum size, has changed color from green to brown or yellow and readily drops from tree (**Figure 10**).

*Prunus persica* *Bombax ceiba* *Juglans regia* *Quercus grifithii* *Erythrina stricta*

Figure 10 Ripe fruits of different plant species

**Leaf fall:** Leaf fall is the stage when leaf is falling or has recently fallen from the plant, but not the one that has fallen due to disturbance or before it has reached the maturity. For evergreen tree, time of leaf fall is not distinct. So, don't record leaf fall event for evergreen plants (**Figure 11**).

**Young leaf**

**Mature leaf**

Figure 11 : Leaf fall

## How to observe and record the phenophase event

Before going to the monitoring site, ensure that your team has the following equipment ready:

1. Phenophase definition guide
2. Observation datasheet, clip board, pencil
3. Binoculars and camera

Make a visit to observation site as per the observation schedule. Check the individual plants tagged for observation from different location. If you are not sure which phenophase to observe, refer species profile page available from BPN website (www.bpn.org.bt). On each visit, besides date and time information, record the following information in the species datasheet for the respective plant phenophase:

- Yes (Y): If you saw that phenophase is occurring
- No (N): If you saw that phenophase is not occurring
- Uncertain (?): If you are not sure about phenophase or haven't observed the phenophase

Besides recording observation data, take picture of phenophase being observed and make sure that picture is clear. An image will be used for validating the phenophase observation of that specific species. It is very important to ensure that your image is clear and of appropriate size to facilitate the phenophase validation.

## When to observe

If possible, observations should be done throughout the year. However, given the school vacation, it will not be possible to carry out the observation throughout the year. As shown in **Table 1**, bar marked with light gray indicates months when students can do a month long observation. And bar marked with dark gray indicates month when students could be involved partially in the observation activity. However, the bar

marked with red indicates the months when observation will not be possible at all, specifically due to winter vacation.

Table 1: Observation schedule for a year

| Winter | | | Spring | | | Summer | | | Autumn | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov |

The observation needs to be carried out every day, from Monday to Sunday. However it is very important to maintain consistency in time of observation. Usually, the observation is recommended during time of day when there is less shadow effect on observation and plant physiological activity is high. As shown in the **Table 2**, the bar marked light grey indicates the time when the observation activity is usually recommended. The bar marked green indicates the time frame beyond which observation is not usually recommended.

Table 2: Daily observation schedule

| 9 am | 10 am | 11 am | 12 | 1 pm | 2 pm | 3 pm | 4 pm |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

For every visit, students are required to observe record and submit the data once for every tree marked or tagged for the observation.

## How to submit the observation data

The recorded observations need to be submitted using online user interface from the HEROES website. User name and password is provided for each user group of schools to login and submit the observation data. In addition to observation data, students are required to submit phenophase image or picture for the respective species taken during the visit. The data submitted by students will go through two-step validation processes: one by focal teacher and one by BPN implementer. On getting through the validation process, the submitted data will be stored in HEROES database.

## How to access the HEROES website:

To access the BPN website, click the URL: www.bpn.gov.bt. This will take you to HEROES website Home Page.

### Home Page

Figure 12: Home Page

Click on '**LOGIN**' bar located at the right-top corner of the page (highlighted with red circle). This should direct you to Login page as shown in **Figure 12.**

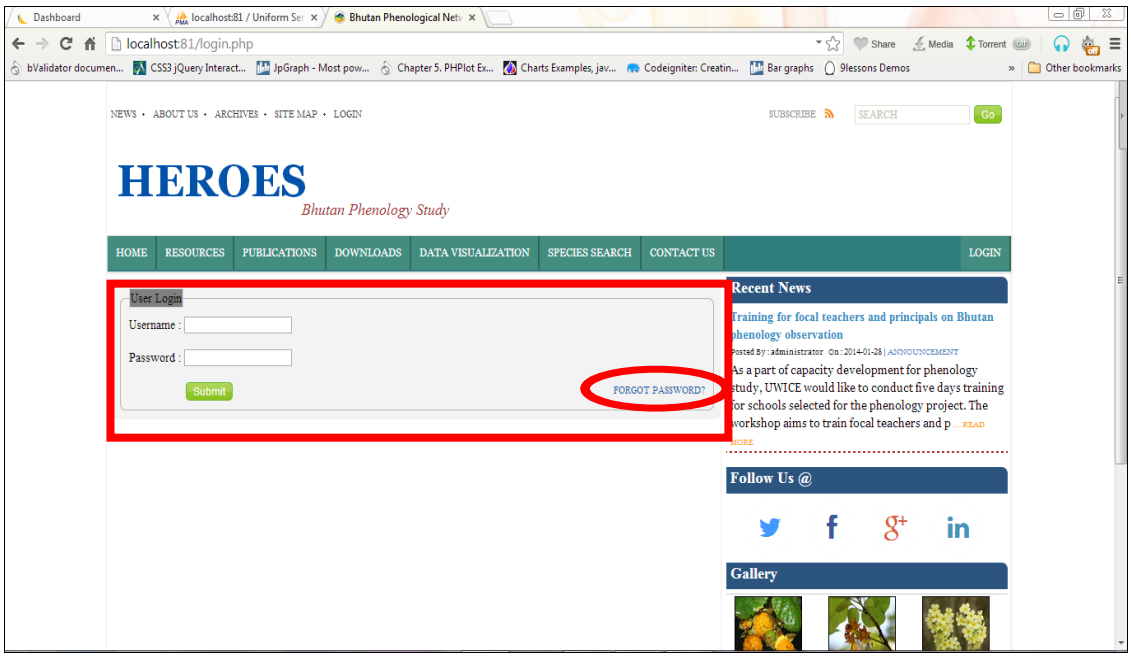



Figure 13: Login Page

## Login using user name and password

Enter an assigned username and password in the login page as shown in **Figure 13**. In case you forget your password, you can reset it by clicking "**FORGOT PASSWORD'** button. You will receive your new password in your registered email. Once you click the '**FORGOT PASSWORD'** button as highlighted by circle in **Figure 12**, you will get the popup page as shown by **Figure 14.**

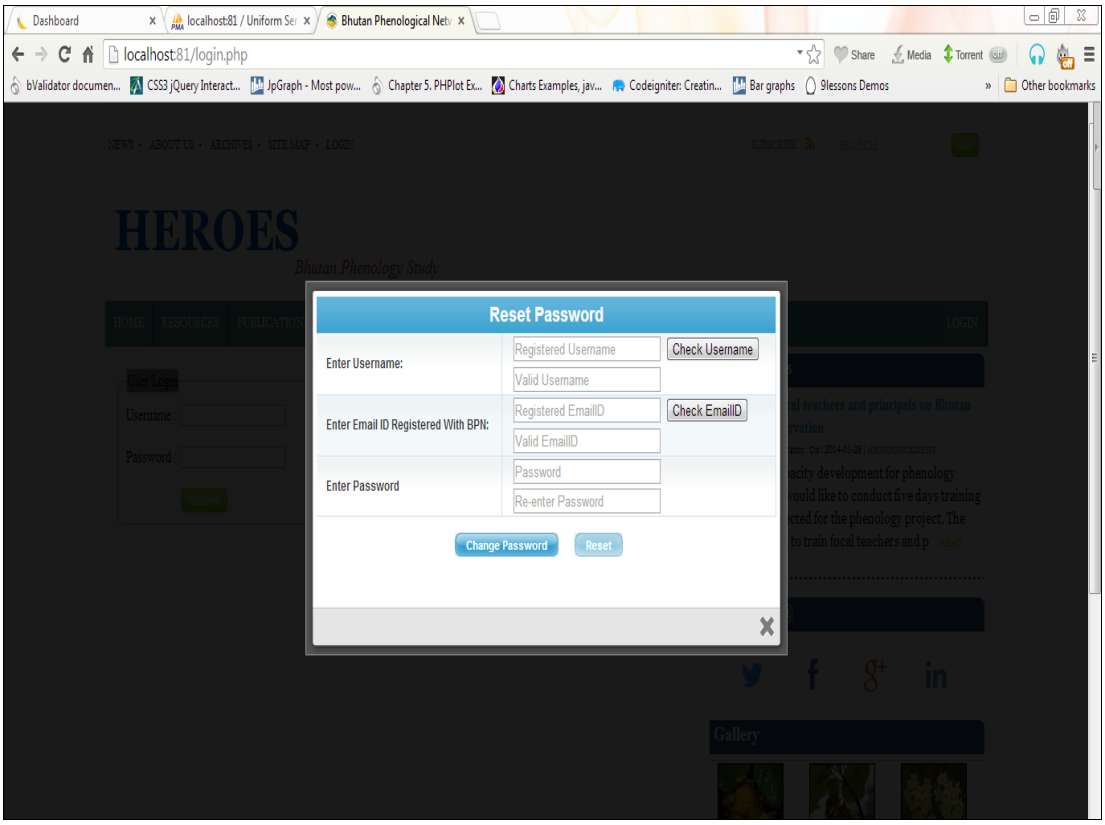



Figure 14: Password reset page

To reset your password you should have your username, valid email with which you registered in the BPN system. Fill the '**Username'** and click '**Check Username'** button. If your username is valid, you should get a popup note "**Valid Username**" indicating that it is the valid registered username. If not, you should get a popup note "**Invalid Username**", wherein you have to crosscheck your username and try again. Repeat the steps for '**Enter Email ID Registered with BPN**'. After that you can set your new password.

**Tips:** To make your password secure, don't keep the password as same as the username. It is also recommended not to keep your contact number OR some common personal information. There are chances that someone can login on your behalf and might result in submitting invalid data. Always remember to logout your account once you are done with your work.

After filling up the details, the '**Reset Password** 'page should appear similar to the page as shown in the **Figure 15**.

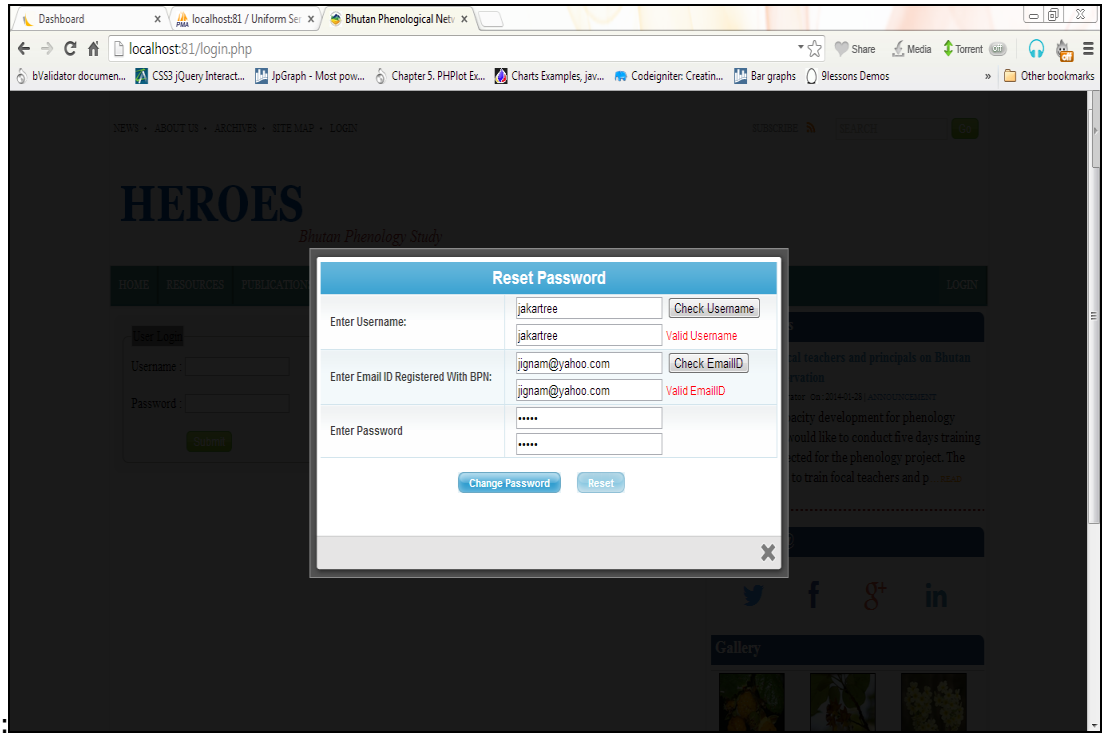



Figure 15: Completed reset password form

## User Dashboard Management

Once you login, you will be directed to individual school or student dashboard. From the dashboard, an individual can edit user information, validate the information, add members, etc. There are two types of dashboards with different privileges: school dashboard and student dashboard (**Figure 16**).

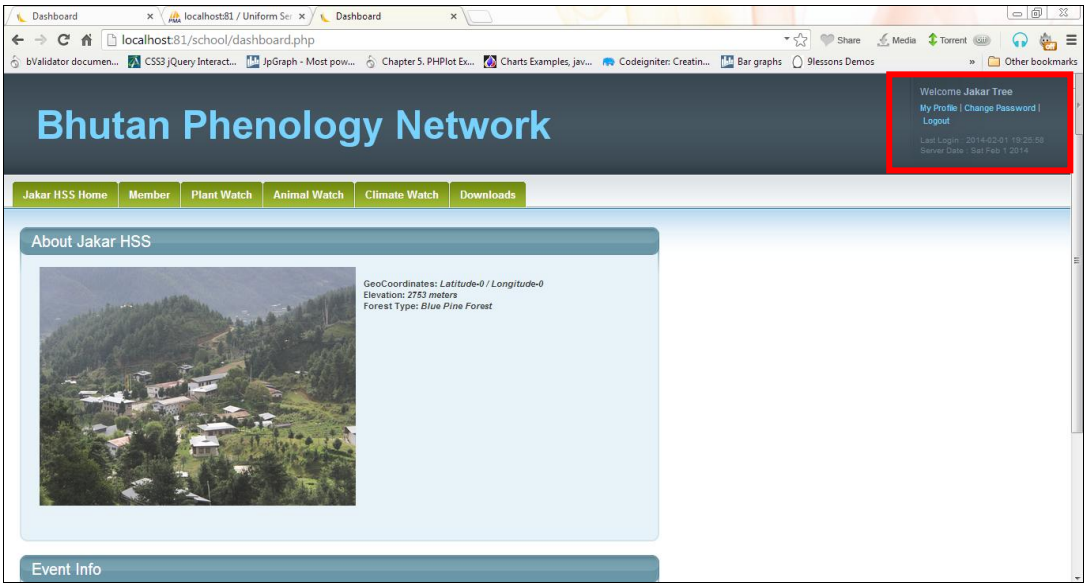



Figure 16: Users' Home Dashboard

The information page at the right hand corner as highlighted in **Figure 16** differs from user to user. It contains the user profile setting, password change and logout options.

### Edit user profile

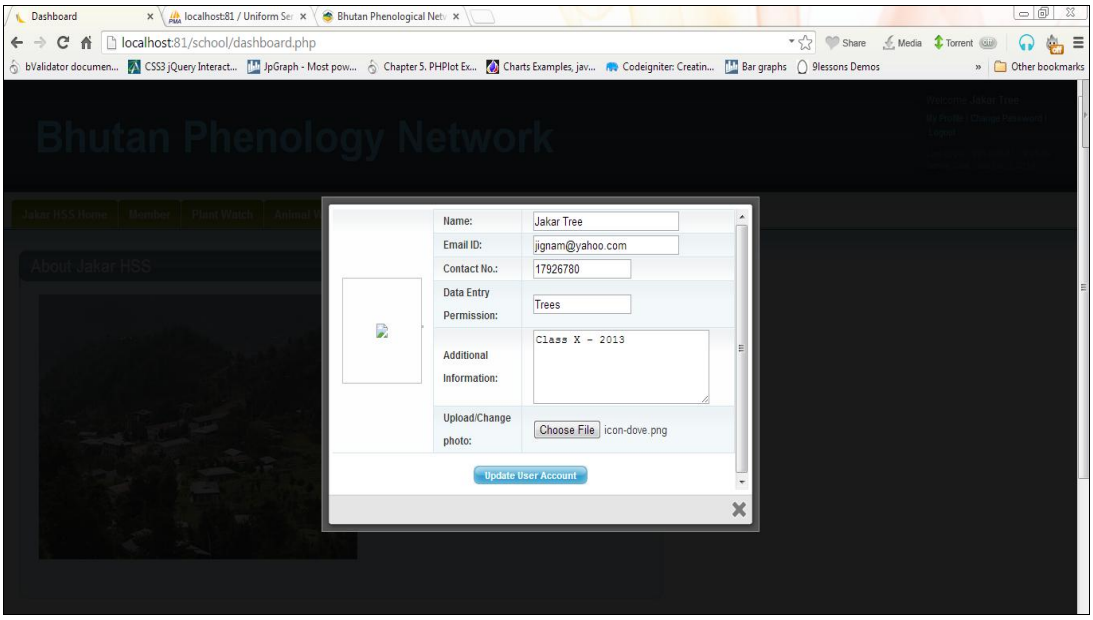



Figure 17: User Profile Edit Form

Any information regarding the user is stored in database: it will be displayed when you try to edit the profile. You can edit your username, email id, contact number, some additional information regarding yourself and your profile photo.

The fully updated user profile page should appear similar to page is as shown by **Figure 18.**

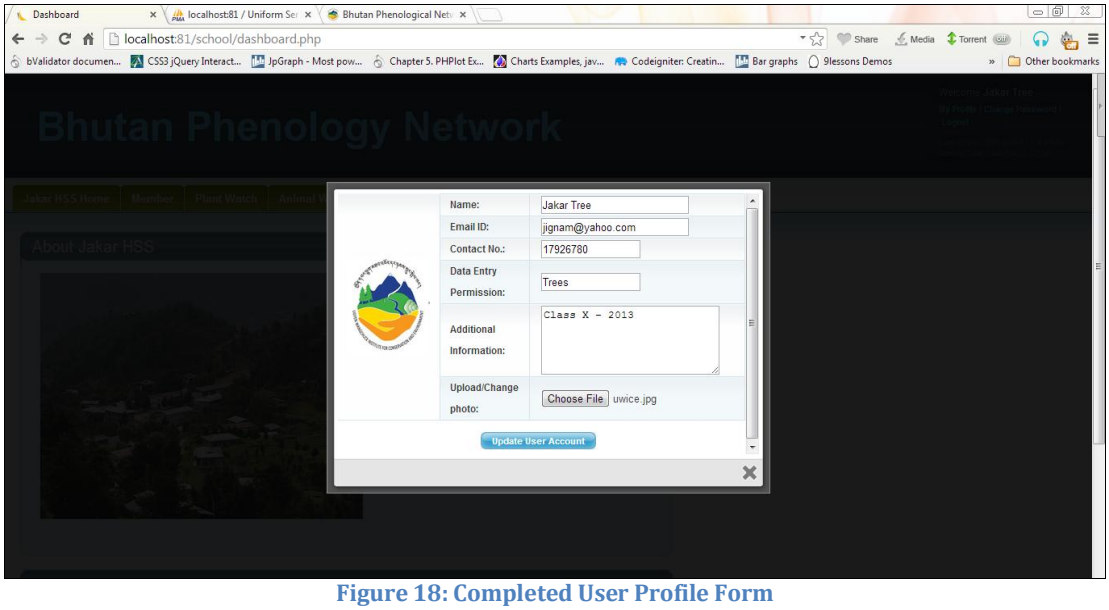



Figure 18: Completed User Profile Form

**Note:** You can upload your profile picture only if the image is in .JPEG or .JPG format and the maximum size of the image should not exceed more than 2MB

## Change password

If you want to change your password after you have logged in, you can do it by clicking on "**Change Password**" which is located at the right corner of the login dashboard as shown in the **Figure 19.**

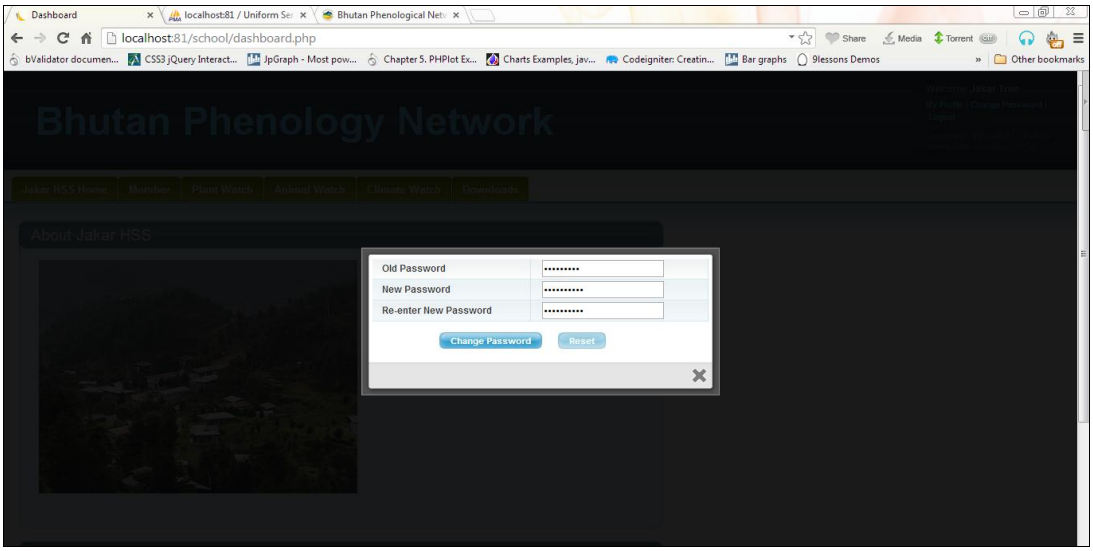



Figure 19: Password change form

**Note:** While creating new password, the new password should match re-entered password. Creation of new password will be unsuccessful if your 'New Password' and 'Re-enter New Password' doesn't match.

## School Dashboard

Only focal teacher has an access to school dashboard. From school dashboard, focal teacher can edit school profile and approve observation data submitted by students. From this dashboard, focal teacher can also monitor the activity of members; number of observations submitted, approved and unapproved, individual student's details, etc. Focal teacher can change/edit the information regarding the site characteristics for each species that is being monitored (**Figure 20**).

Figure 20: Members page

**Student Dashboard**

Unlike focal teachers' dashboard, students' dashboards don't have the privilege to edit or change schools or other members profile page. From the student's dashboard, students can edit their own profile, carry out the data submission task, validate their own data and upload the image. Students can change/edit the information regarding the site characteristics for each species that is being monitored by their group.

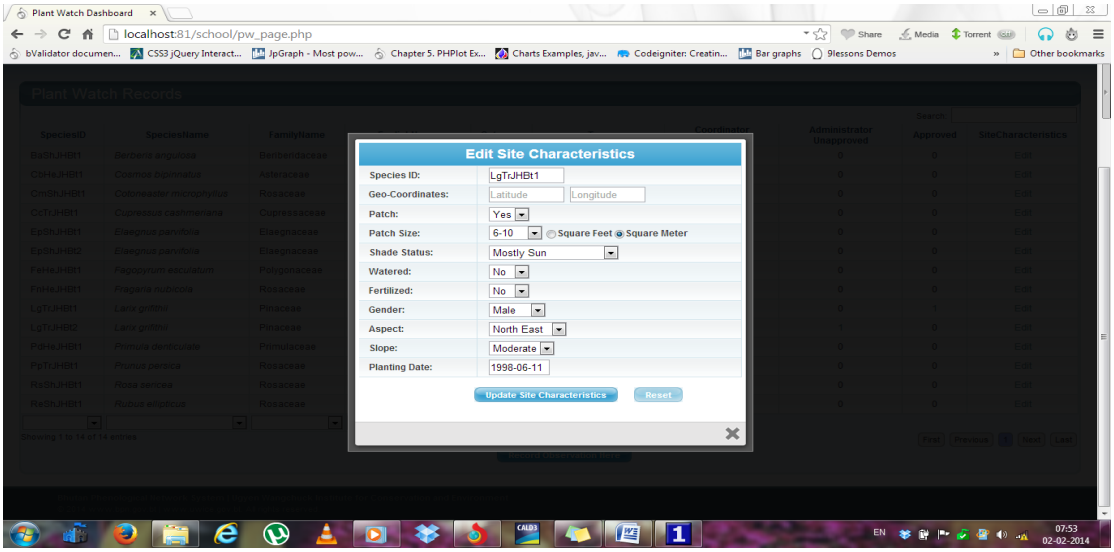



Figure 21: Site characteristics page

Note: It is advised to change the site characteristics only once: As the site characteristics of the plant are going to remain same unless the plant is uprooted or relocated.

## Phenophase visualization

The phenophase event for species for the respective school can be visualized from the school and student dashboard. For that, click '**Home Page'.** Under **'Home Page'** there is "**Event Info'** page. From the drop down menu, select species of tree, shrub or herb for which you want to see the phenophase. Click the specific phenophase '**Budburst Period'**, **'Young Leaf'**, '**Flowering**' and **'Fruiting'**, from the drop down menu to see the images as shown in the **Figure 22**.

Figure 22: Phenophase visualization page

## Enter your observation: For students

From the student's dashboard, click '**Record Observation Here'**. If you want to view species profile along with observation data form, check the box next to '**View Species Profile'**. Students can submit the observation data only for one category (tree, shrub, and herb) assigned to the group. Select either single or multiple plants for which they would like to enter the observation. Once the plant is selected, click '**Enter Observation'** as highlighted by circle in the **Figure 23.**

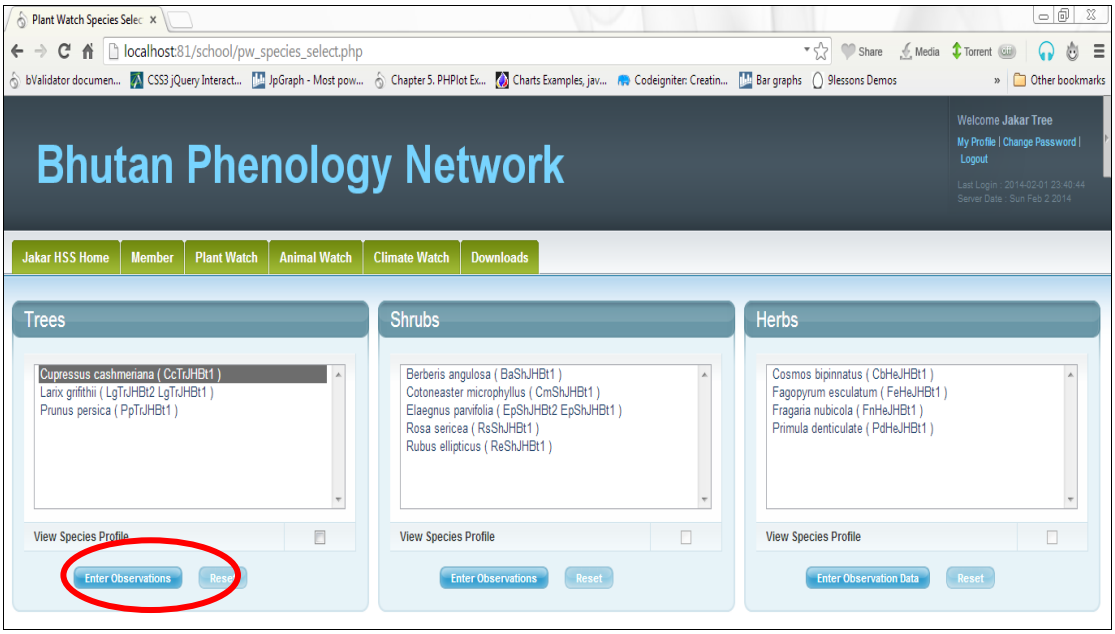



Figure 23: Species selection page

On the side bar, as highlighted by red square box in the **Figure 24**, species profile page with an instruction on what, how and when to observe is displayed for each selected species. Refer the species profile page if there is need for any guidance on identifying plant phenophase, observing and recording it.

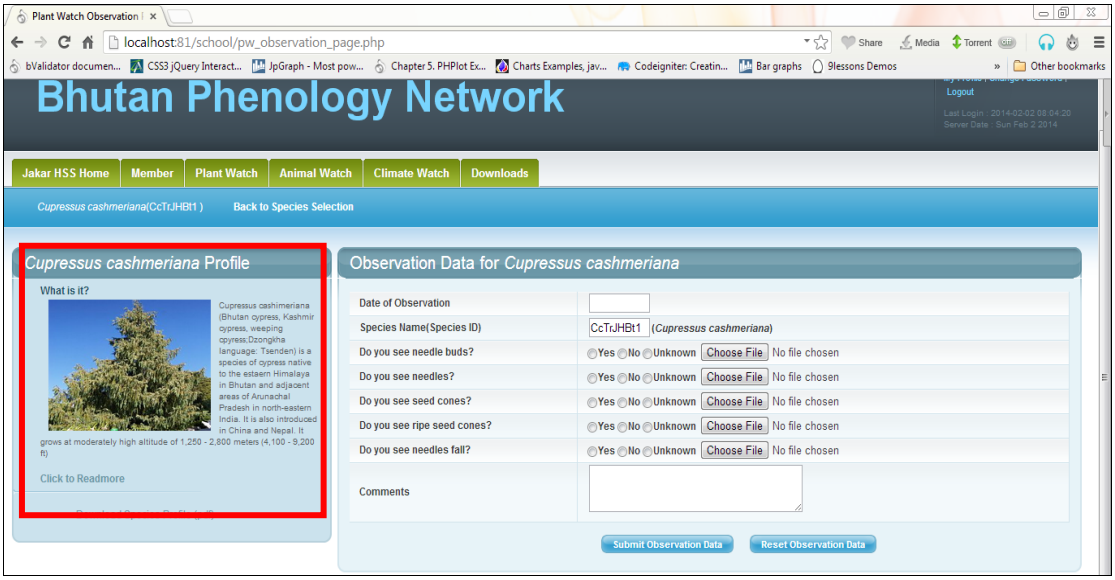



Figure 24: Observation entry page

Also, refer the filled up form for a given species, and accordingly select the choice available for each phenophase question marked with arrow (**Figure 25**). Enter the date by clicking '**Date of Observation'** located at the top of the page. If you have seen the given phenophase, click '**Yes**', if not '**No**'. However, if you are not sure about the phenophase or haven't visited the site, click '**Unknown**'. Based on number of species, multiple data entry can be made for one time data submission.

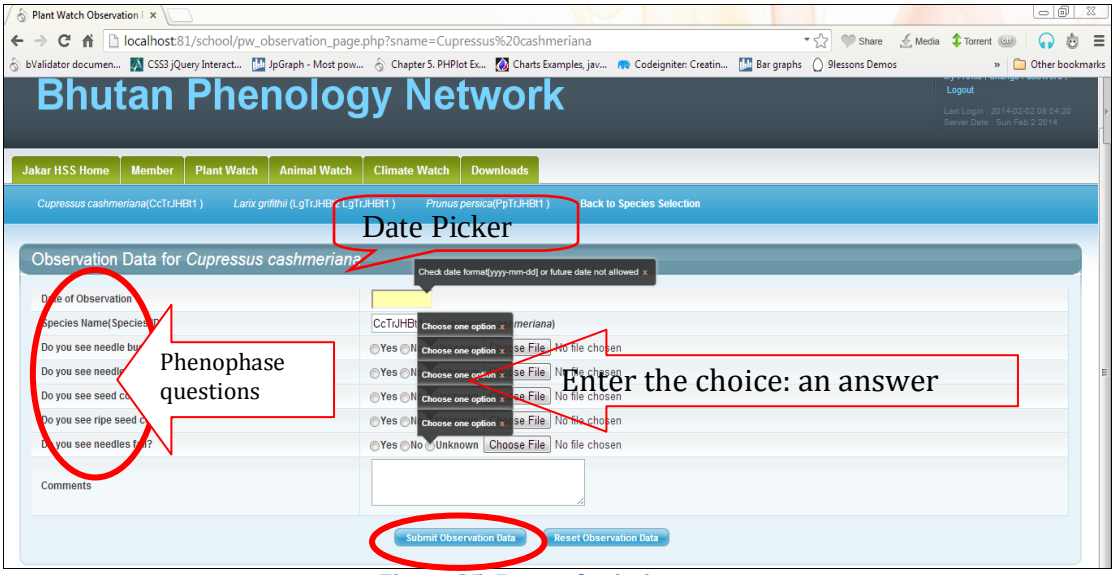



**Figure 25: Data submission page**

Upload the image for the respective phenophase by clicking '**Choose File**' (**Figure 25**), if the event is reported for the first time. Please note that for any particular phenophase event, only one image upload is permitted. So, make sure that you identify the phenophase correctly and assign it to specific phehophase event prior to uploading the image. Prior to image upload, ensure that it meets the following specifications:

- Format: JPEG/JPG
- Image size: less than or equal to 2MB
- Resize your image 800x600: this will automatically reduce size to less than 2MB

After having entered the data correctly, click **'Submit Observation'** to submit the data (highlighted by red circle in the **Figure 25**)

The submitted data will go through the validation process: focal teacher and website administrator. Student can check the status of the submitted data by clicking "**PlantWatch**" to display the list of all the plants for their groups. On this page, refer "**Approved**" and "**Unapproved**" column to determine whether submitted data has been approved or unapproved for any specific plants. Besides that, by referring the number/digit under respective column (**Approved** and **Unapproved**), students can also know how many observations they have submitted, how many have been approved and how many are yet to be approved (**Figure 26**). On submission of data, the list is updated automatically in the table.

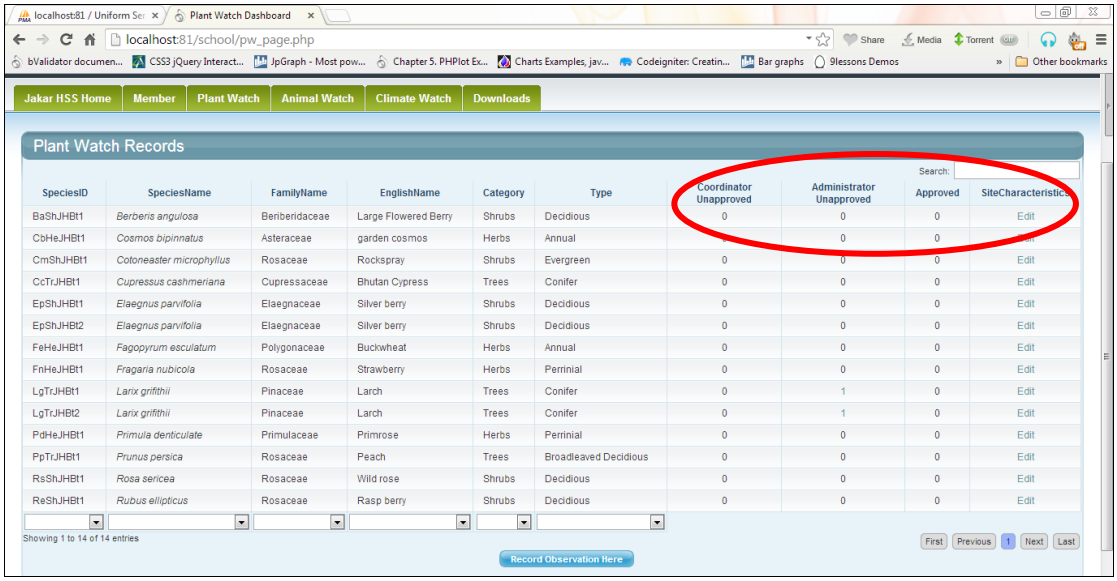



Figure 26: Submitted data status

If changes need to be made, make sure you do it before it gets approved. For that click the number/digit for specific species under "**Unapproved**" column. This will direct you to '**Edit page**" as shown in the **Figure 27**. Click '**Edit**' and make the necessary changes and resubmit the data.

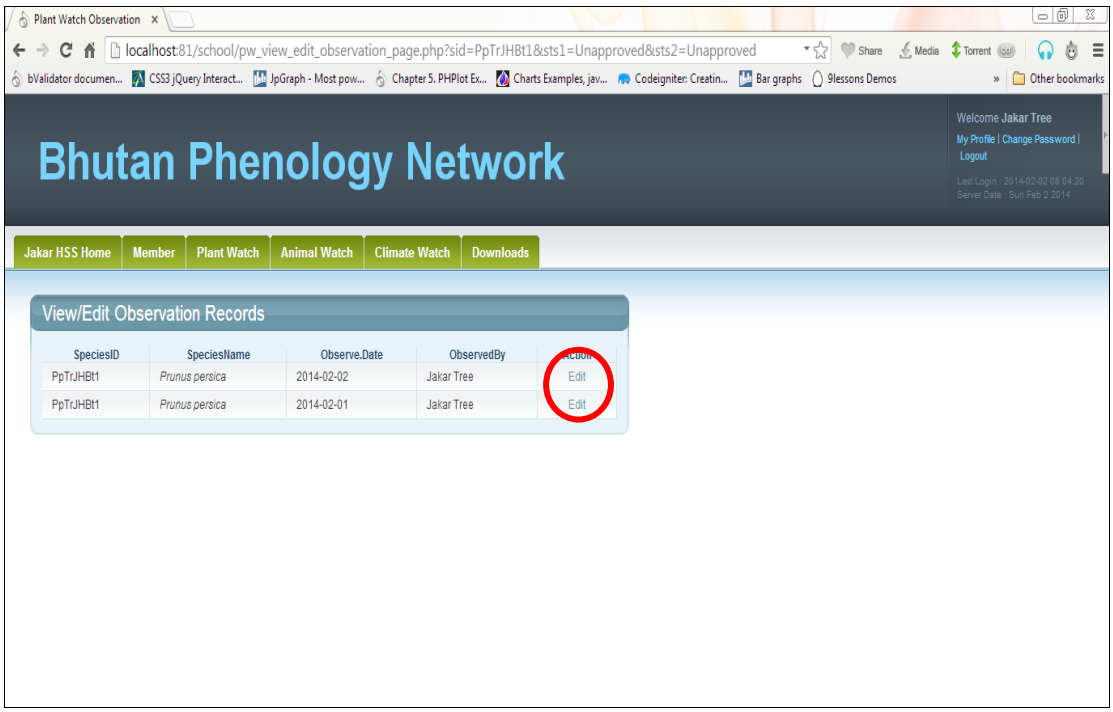



Figure 27: Data edit page

If you want to see the event photo, which was uploaded, click onto "View Image". This will direct you to popup window with an image submitted by you (**Figure 28**)

Figure 28: Image popup window

**Note**: If you wish to change the event photo you can do that by uploading as same as before but keep in mind that you can do that only for that particular date on which the first phenophase event was observed.

## Data validation: For focal teacher

Once students submit the observation data, the first validation or approval should be done by the respective focal teacher. For that, click '**PlantWatch**' and scan for the data submitted by students. If there is any, the record will be displayed under "**Coordinator Unapproved**" column. Click the number/digit under that heading and click '**Approve**'. Once you click '**Approve**' button, the submitted data is approved by the coordinator and will be sent for final approval or validation to the website administrator. Also, focal teacher can view the status of the data approved by him/her from the same page (**Figure 29**). For that, refer the "**Administrator Unapproved Page**" or "**Approved Page**" column as highlighted by circle in **Figure 29**.

When a focal person clicks on the number, he/she can't edit the data submitted by the student since his/her duty is to just approve the data. However if the coordinator has submitted data on student's behalf using his own account, he can edit and update the data. Usually, the submission of data on behalf of student is not recommended.

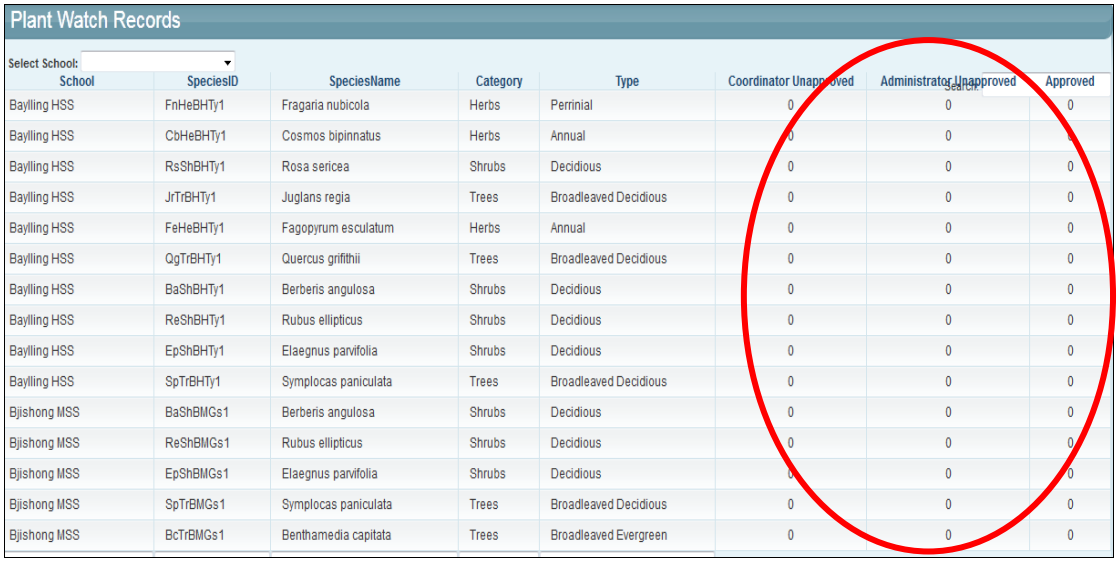



Figure 29: Data status page

## Download: Observation form and the raw data

Focal teacher and students can download the blank observation form or filled up form (raw data) from their respective dashboard. Blank form for specific plant species are required to be downloaded for recording the observation data during the field visit. Select the species for which they need the blank form, and click "**Download Form**". The form should be downloaded as PDF format in your computer. You should note that for each species, there is unique ID assigned and it is marked in the form as shown in the **Figure 31**.

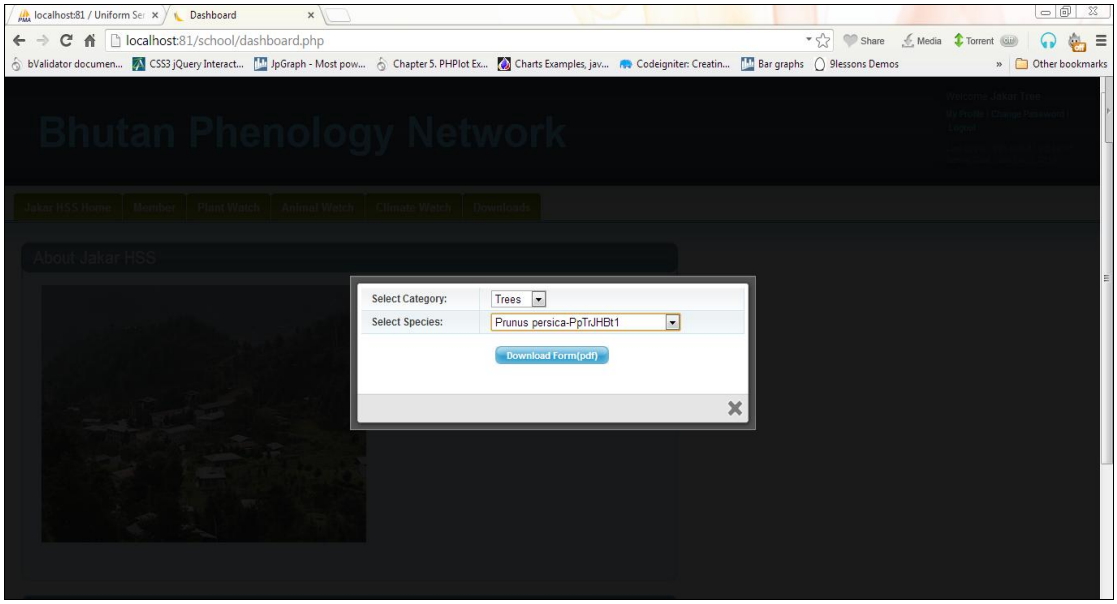



Figure 30: Blank form download page

Focal teacher and students can also download the filled up form that they have submitted. This is necessary if you want to save the copy of the data in printed format or back up the data that you have submitted for records. The filled up form is downloaded as PDF format. For that, click '**PlantWatch**' and select the species for which you want to get the data. Click '**Download Data'** to download the submitted data or filled up form.

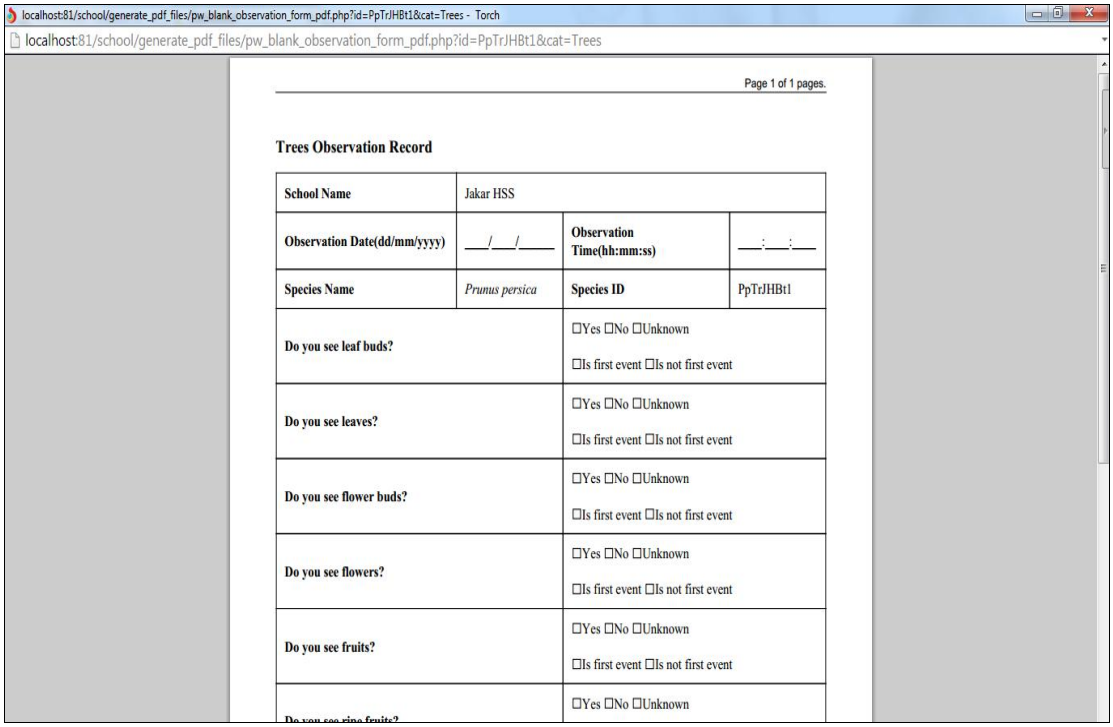
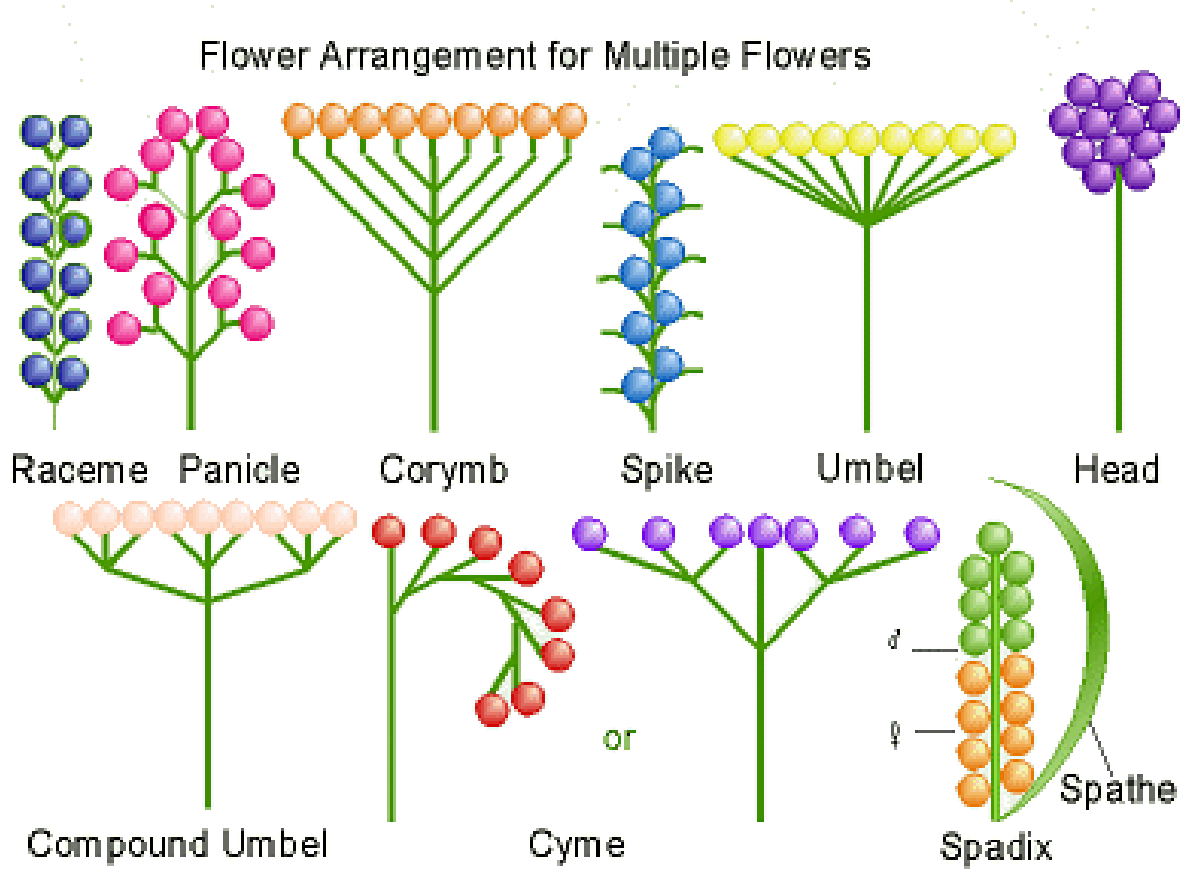



**Figure 31: Filled up form**

While filling up observation form in the monitoring site, please don't forget to fill it correctly. Don't forget to specify if the event is the first event or not. Based on that, take an image of the first event and upload it as per the specification: size and format

***Appendix I***


Flower Arrangement for Multiple Flowers
Raceme
Panicle
Corymb
Spike
Umbel
Head
Compound Umbel
or
Cyme
♂
♀
Spathe
Spadix

## *Appendix II*

| Sl.no | Habit | Types | Description | Pictures |
|---|---|---|---|---|
| 1 | Tree | Deciduous<br>Evergreen | An upright, woody perennial plant with one main stem (tree trunk) and height > 3m.<br><br>Examples: Fir, Spruce, Walnut, etc | |
| 2 | Shrub | Deciduous<br>Evergreen | An upright woody perennial plant with multiple main stem and height commonly < 5 m.<br><br>Examples: Wild Rose, Rhododendron, etc | |
| 3 | Herb | Annual<br>Biannual<br>Perennial | Non-woody flowering plants. Stem usually soft and flexible.<br><br>Examples: Primrose, Strawberry, Grasses, etc | |

## *Appendix III*

| | Phenophase title | Herbs | Deciduous tree/shrub | Broadleaved evergreen tree/shrub | Evergreen conifer | Deciduous conifer | Examples |
|---|---|---|---|---|---|---|---|
| **Vegetative phenophase** | Initial growth | X | | | | | *Fragaria nubicola, Primula denticulate, etc* |
| | Breaking leaf bud | | X | X | | | *Juglans regia, Benthamedia capitata,etc* |
| | Young leaves | | X | X | | | *Benthamedia capitata, etc* |
| | Falling leaves | | X | | | | *Prunus persica, etc* |
| | Breaking needle buds | | | | X | X | *Pinus roxburghii, Larix grifithii, etc* |
| | Young needles | | | | X | X | *Pinus bhutanica, Larix grifithii, ect* |
| | Falling needles | | | | | X | *Larix grifithii, etc* |
| **Reproductive phenophase** | Flower or flower buds | X | X | X | | | *Fragaria nubicola, Prunus persica, Benthamedia capitata, etc* |
| | Open flowers | X | X | X | | | *Fragaria nubicola, Prunus persica, Benthamedia capitata, etc* |
| | Pollen cones | | | | X | X | *Pinus roxburghii, Larix grifithii, etc* |
| | Open pollen cones | | | | X | X | *Pinus roxburghii, Larix grifithii, etc* |
| **Fruits/seeds** | Fruits | X | X | X | | | *Fragaria nubicola, Prunus persica, Benthamedia capitata, etc* |
| | Ripe fruits | X | X | X | | | *Fragaria nubicola, Prunus persica, Benthamedia capitata, etc* |
| | Recent fruits or seeds drop | X | X | X | | | *Fragaria nubicola, Prunus persica, Benthamedia capitata, etc* |
| | Unripe seed cones | | | | X | X | *Pinus roxburghii, Larix grifithii, etc* |
| | Ripe seed cones | | | | X | X | *Pinus roxburghii, Larix grifithii, etc* |
| | Recent cones or seed drop | | | | X | X | *Pinus roxburghii, Larix grifithii, etc* |

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