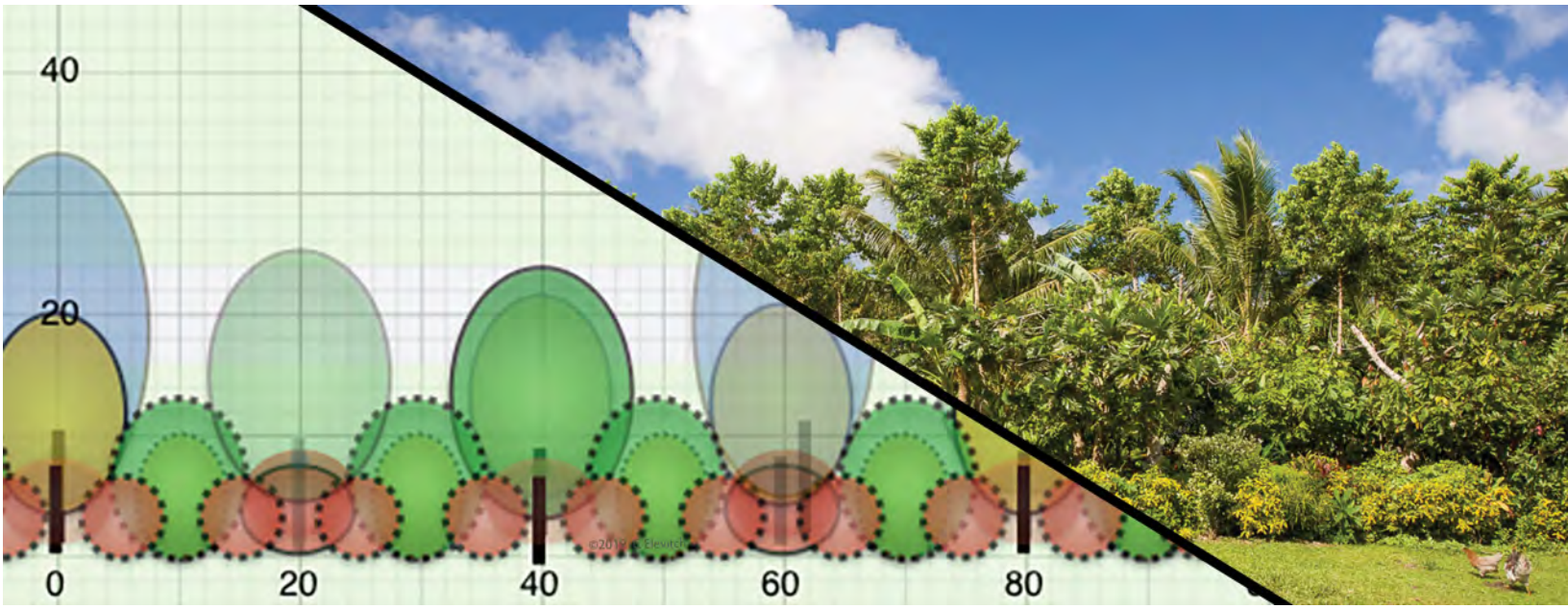

Agroforestry Design Tool™ (AgroforestryX.com) User Manual

Common questions with pictorial answers

Craig Elevitch, Neil Logan, and Sophia Bowart

Authors: Craig Elevitch, Neil Logan, and Sophia J. Bowart

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About the tool

The Agroforestry Design Tool™ (AgroforestryX.com) is a collaboration of Permanent Agriculture Resources and Forest Agriculture Research Management Center (FARM Center). The lead designers are Craig Elevitch and Neil Logan with technical support provided by Sophia Bowart. Erin Marshall provided engineering support and implementation expertise.

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1 Introduction

It is commonly said, “There are no recipes for agroforestry.” The most successful agroforestry projects are tailored to site conditions, project goals, and personal preferences. This tool provides guidance in designing multistory agroforests which can be applied to food and/or timber production, native habitat restoration, and other user goals. Multistory agroforests have the potential to regenerate degraded soils, restore biodiversity, sequester carbon, and provide many other ecosystem services while producing abundantly.

The Agroforestry Design Tool™ (ADT) helps the user to select species, create a geometric planting layout, and to visualize how the planting will look over time. The ADT should be seen as assisting the user in the design process, but it is not a replacement for the expertise of those familiar with local environmental and economic conditions. Choosing local consultants with previous experience in your area is ideal, when available. The ADT creators’ consulting company offers services in design, implementation, management and training in regenerative dynamic agroforestry systems.

Expert, customized consultation should always be sought prior to implementation.

1.1 What is this manual for?

This manual guides the user step-by-step through the process of using the ADT and answers many common questions that come up while developing a design with the ADT. Those who are unfamiliar with agroforestry design may use this manual to guide them in the process of making use of the ADT.

1.2 What is multistory agroforestry?

Multistory agroforestry systems are complex, diverse plantings of trees, shrubs, vines, and herbaceous plants occupying two or more canopy layers. One could say that all other agroforestry systems are variations to some degree of multistory agroforestry.

1.3 Why multistory agroforestry?

Multistory agroforestry systems are complex, diverse plantings of trees, shrubs, vines, and herbaceous plants occupying two or more canopy layers. Indigenous examples of multistory agroforestry still exist throughout the world and can serve as models for modern agroforestry systems (see example in Figure 1).

The benefits of multistory agroforestry include:

- Cultivation of multiple crops that provide multiple products
- Higher total yield than monocultures

- Increased resilience to environmental stressors
- Resistance to outbreaks of pests and diseases

The drawbacks of multistory agroforestry include:

- Possible competition for space, light, and water, which must be managed.
- Management requires advanced knowledge and experience.

Figure 1: This indigenous multistory agroforestry system is representative of such traditional systems throughout the Pacific islands. Species include breadfruit, cacao, banana, noni, coconut, and poumuli. The Agroforestry Design Tool™ uses such systems as models for planning modern agroforestry.

Translating complex indigenous agroforestry systems to our modern context can be done in many ways. In our system inspired by numerous agroforestry experts throughout the world, we simplify the planting by organizing the planting in rows (Figure 2). Planting in rows allows for efficiency of management and access. It also facilitates in the planning process as well as training in management of the various canopy layers and crops by providing a standardized framework.

Conceptually, our standardized framework is based upon visualizing the agroforest with several canopy layers (Figure 3, see Elevitch et. al 2018 for additional

information). This perspective allows us to look at the indigenous agroforest of Figure 1 in a context of canopy layers (Figure 4), upon which this tool is based.

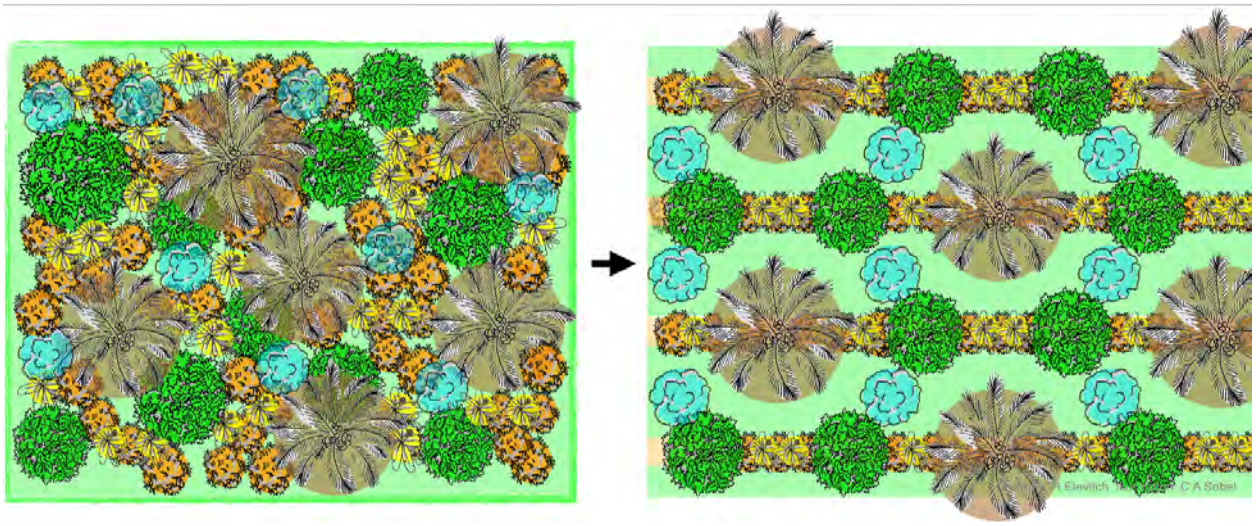


Figure 2: Organizing the species into rows allows for systematic planning, management, and access pathways.

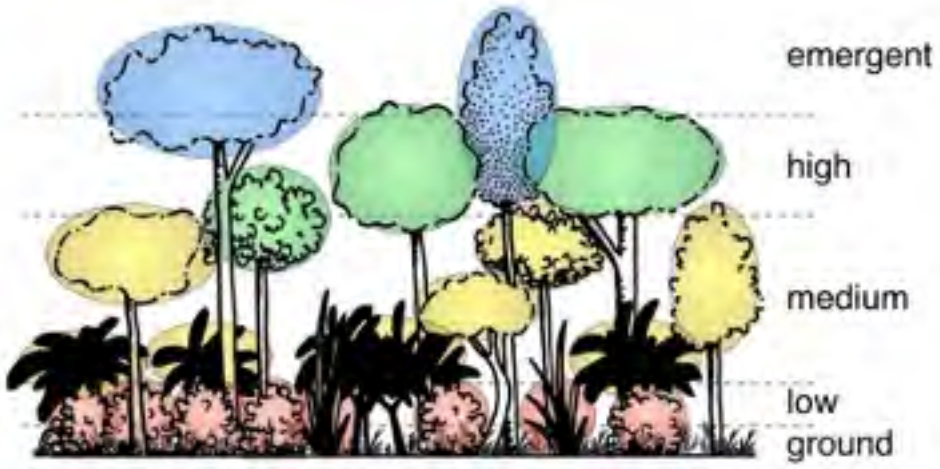


Figure 3: The ADT is based upon multistory agroforest canopy layers, color coded as shown here.

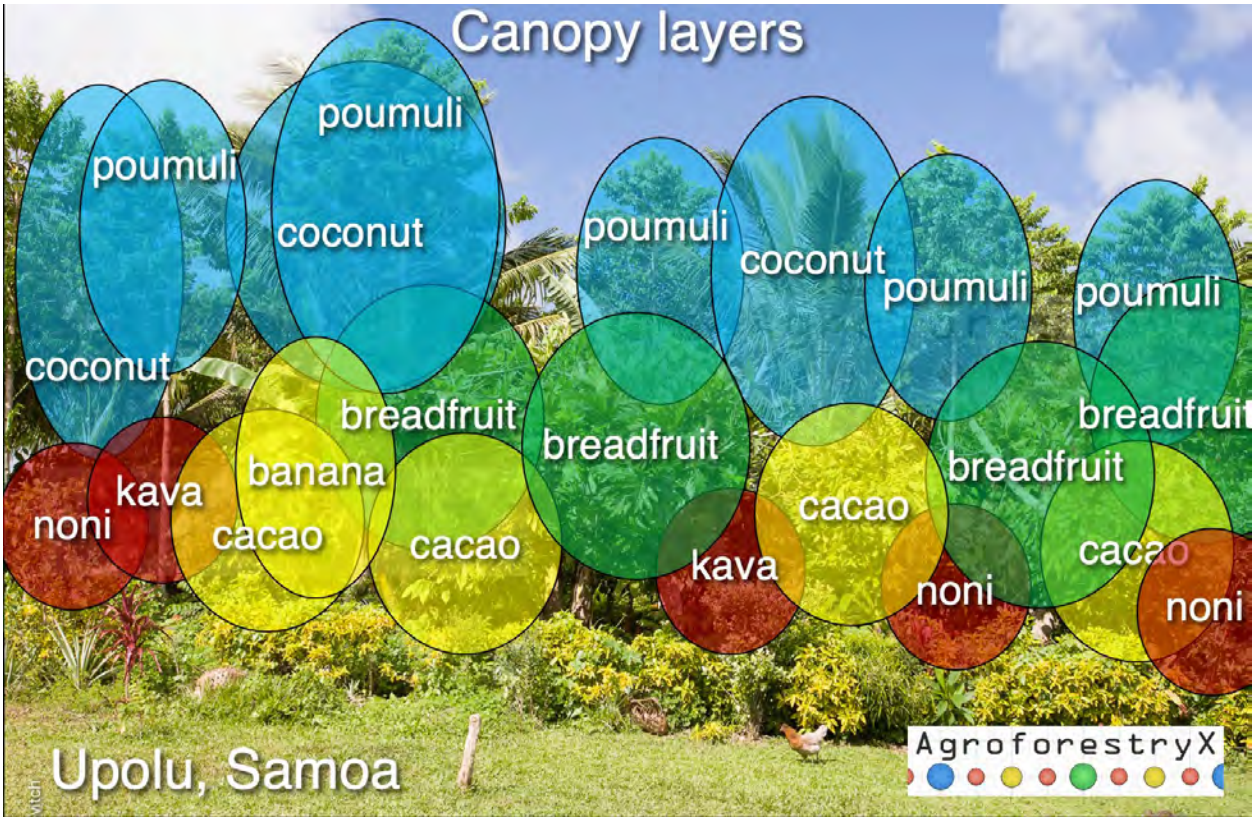


Figure 4: Canopy layers of example of Figure 1 shown with their color-coded canopy heights.

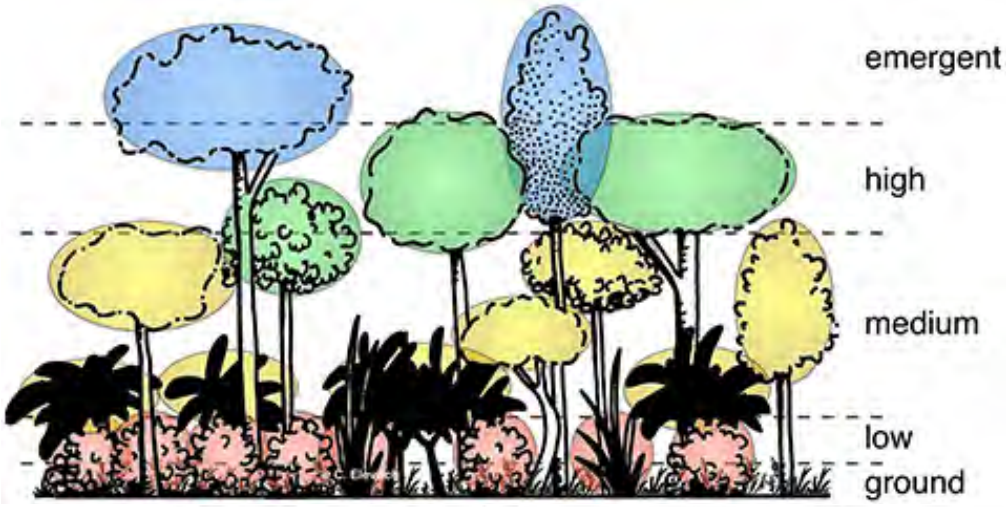
1.4 Why use this tool?

The Agroforestry Design Tool™ helps the user in selecting species, a geometric planting pattern, and in visualizing how the planting will look over time. The ADT begins with your environmental data for a specific project, followed by guidance for selecting a planting configuration and a suite of species. The ADT can assist you in following the species diversity requirements of the U.S. Department of Agriculture Natural Resources Conservation Service's “PI For/AgFor Technical Note 11—Mixed Agroforest Specification” or a regenerative agroforestry standard (Elevitch et al, 2018). Once species are selected, you have the option of selecting the number of each species and changing the pruning sizes of managed crops. The next step presents visualizations of the planting configuration you have chosen, followed by the option to export your project plan to your device as a pdf file. The ADT provides users with the species, layout and ability to visualize their multistory agroforestry planting

1.5 Multistory canopy layers

The Agroforestry Design Tool is based upon positioning plant species that occupy different forest layers in orientation to each other in time and space (short-, medium-, and long-term crops). The arrangement of crop species in both time and

space leads to an agroforest designed to mimic a natural forest ecosystem in both structure and function. The layer each species occupies is determined by light needs and niche occupied in their respective ecosystems of origin. The layers are color-coded to assist the user in interpreting their planting configuration. The color system we use for the different layers is illustrated in the figure below, with the approximate relative heights of the species (if allowed to grow naturally without pruning) given in the table.



Height ranges of the various layers and their icon colors illustrated in the templates.

Stratum (layer height class)	Icon color	Light requirements	Long-term species (4+ years)	Medium-term species (0–4 years)	Short-term species (0–2 years)
Emergent		Full sun	40+ ft	12+ ft	not illustrated
High		≈80% sunlight	≈18–40 ft	≈6–12 ft	not illustrated
Medium		≈60% sunlight	≈10–20 ft	≈4–8 ft	not illustrated
Low		≈40% sunlight	≈2–12 ft	≈2–6 ft	not illustrated
Ground	not illustrated	20–80% depending on location relative to trees	—	—	—

Figure 5: Layers of the multistory agroforest design. Height ranges of the various layers and their icon colors are given in the table.

1.6 Limitations of the tool

The ADT should be seen as assisting the user in the design process, but it is not a replacement for the expertise and knowledge of local environmental and economic conditions. The ADT has several limitations to be aware of:

- The species database is currently selected for the U.S.-affiliated Pacific Islands (although many of the species are found throughout the tropics).
- This tool is not meant as a replacement for traditional or indigenous agroforestry knowledge, but only as a planning and educational assistant.

- The ADT assumes that the intended planting site has been prepared and is in good condition for planting.
- The planting configurations are given in the form of 100 ft x 100 ft (30 m x 30 m) patterns, which will need to be adapted for the specific shape and size of the site by the user.
- Suggested planting configurations assume the user is starting with an open field, although the user can adapt their chosen pattern to existing vegetation manually after downloading the design.
- The ADT does not consider integration of livestock.
- The ADT currently operates in imperial units (feet, inches), although environmental data for the site may be entered in metric units.

1.7 How to use this tool

Users begin by setting up what we call a 'project', which covers a field that will be planted with the same planting pattern throughout and that has similar environmental conditions throughout. The next step is to choose from our selections of planting patterns, followed by selecting the species you intend to plant. In the next step, you can select how many of each species you will plant, as well as the sizes at which they will be pruned. A series of visualizations are then generated, in various views, including two animations for growth over the first 15 years. Finally, a summary report for the design is generated along with a project plant list (see Figure 6).

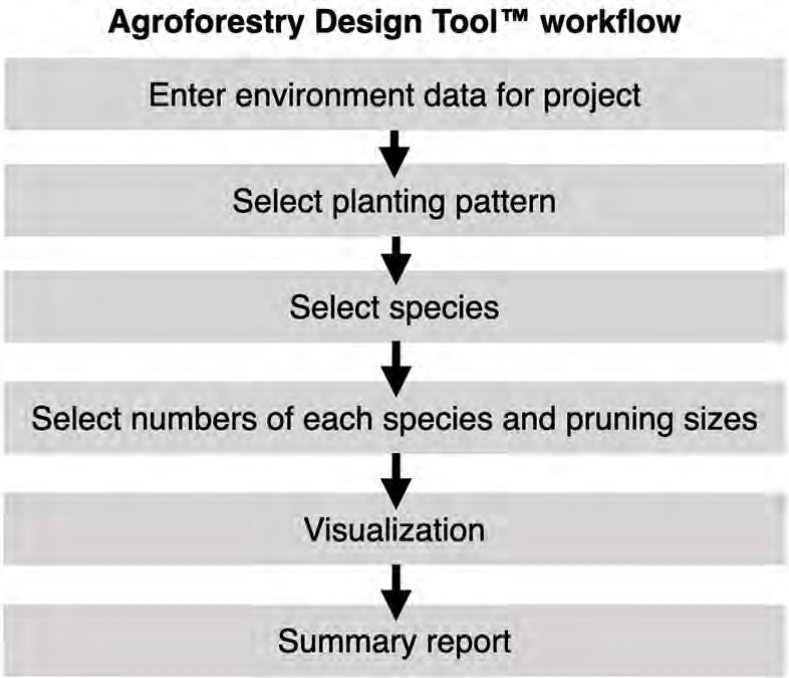


Figure 6: Design steps of the ADT.

2 Home page

The home page gives an overview of the ADT's capabilities, summarizes limitations, and gives additional background information. The top menu allows users to set up an account, login to their existing account, and link to the support page (Figure 7).

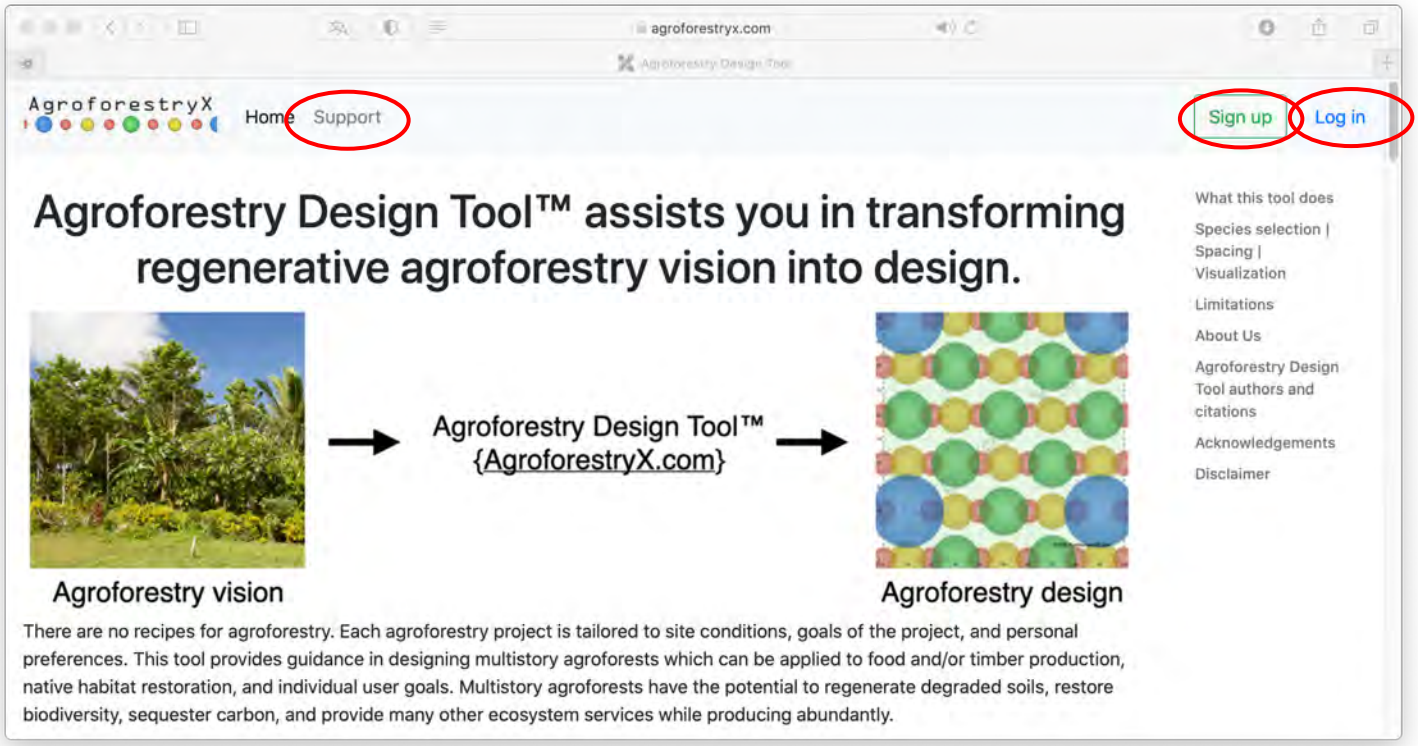


Figure 7: The home page includes links to create a free account, login to an existing account, and visit the support page.

3 Sign Up

3.1 How do I create an account?

Go to the sign-up page at https://www.agroforestryx.com/signup (Figure 8). Fill in the required fields and accept the terms to create your free account.

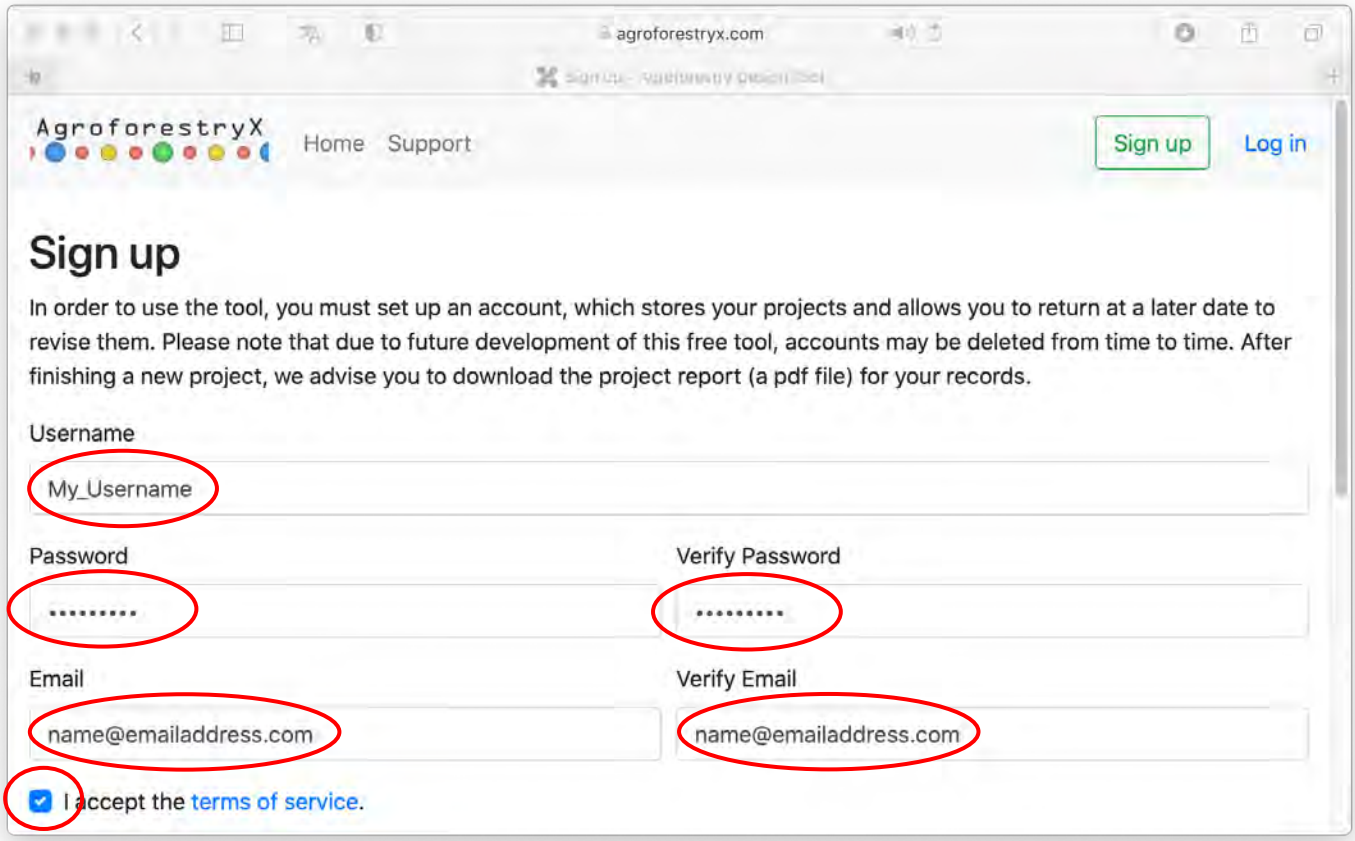


Figure 8: Sign-up page showing fields that need to be completed to set up a free account.

3.2 What happens with my account information?

Your account information and project data are stored by our system so that you can return to your projects and revise them as desired or create additional projects. Your account information is not shared with any third parties.

4 Log in

4.1 How do I log in to my new account?

Go to https://www.agroforestryx.com/login. Type your username and password where prompted and click the "Submit" button (Figure 9).

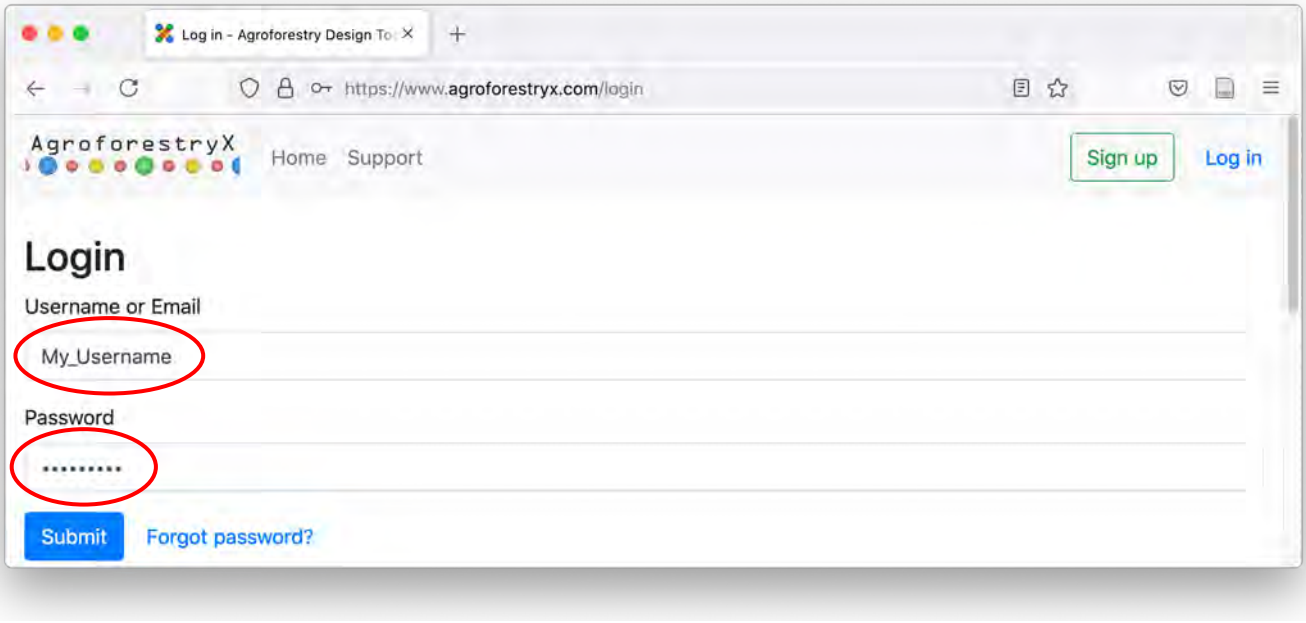


Figure 9: Login screen

4.2 Can I share an account with someone else?

Yes, that is fine.

4.3 Can I log into my account from multiple computers/browser windows?

Yes, however, if a project is being worked on simultaneously from two different computers, project revisions may lead to unexpected results. Therefore, *a project should only be worked on from one computer at a time*.

4.4 What is the best browser to view the tool with?

We have tested the tool with Safari, Firefox, Chrome, and Opera and all browsers work well. Minor page formatting issues may arise in Firefox and Safari.

5 Create new project

5.1 How do I create a new project?

Upon successful log in you will be directed to your projects page. Click on the “New project” button to create a new project (Figure 10). You may also create a new project by duplicating one of your existing projects and then editing it (Figure 11).

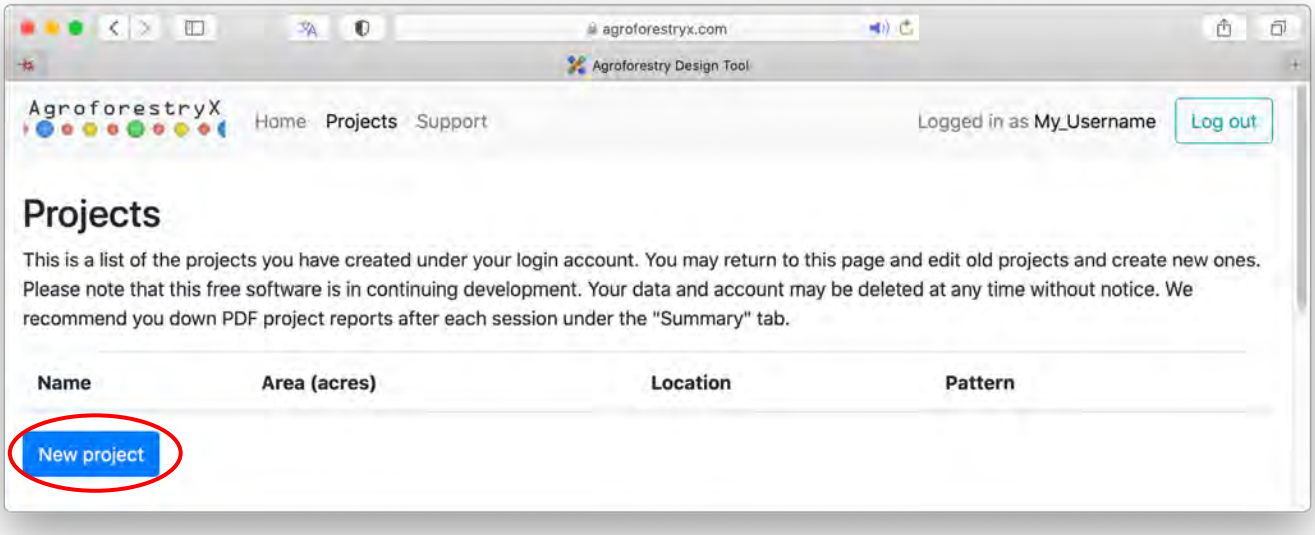


Figure 10: Setting up a new project.

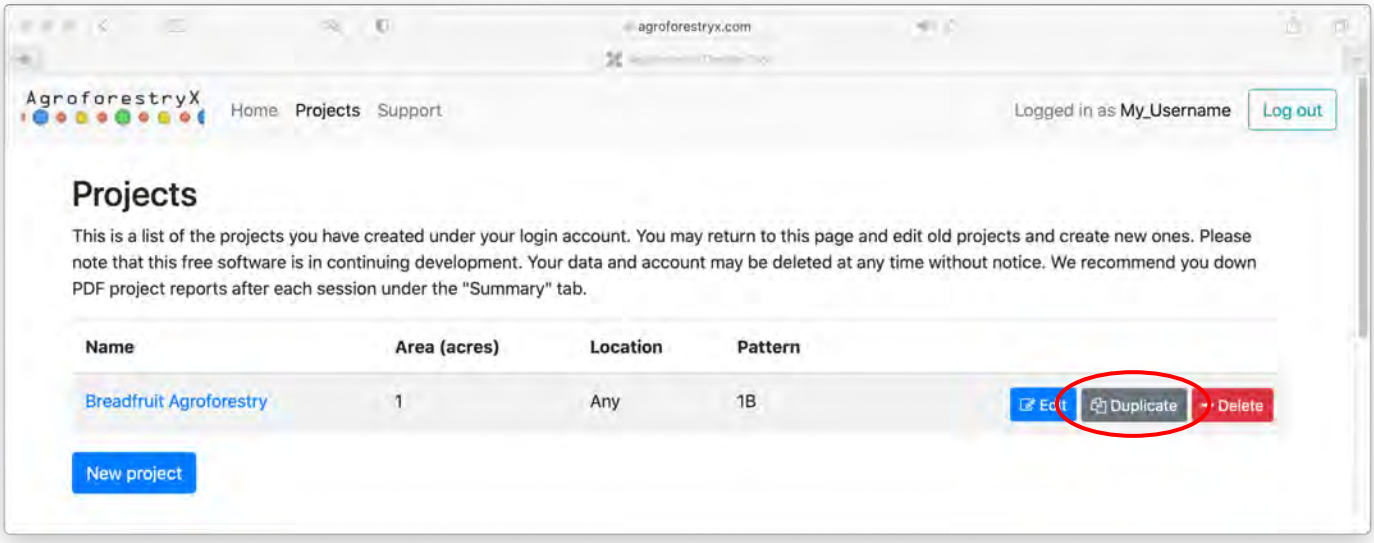


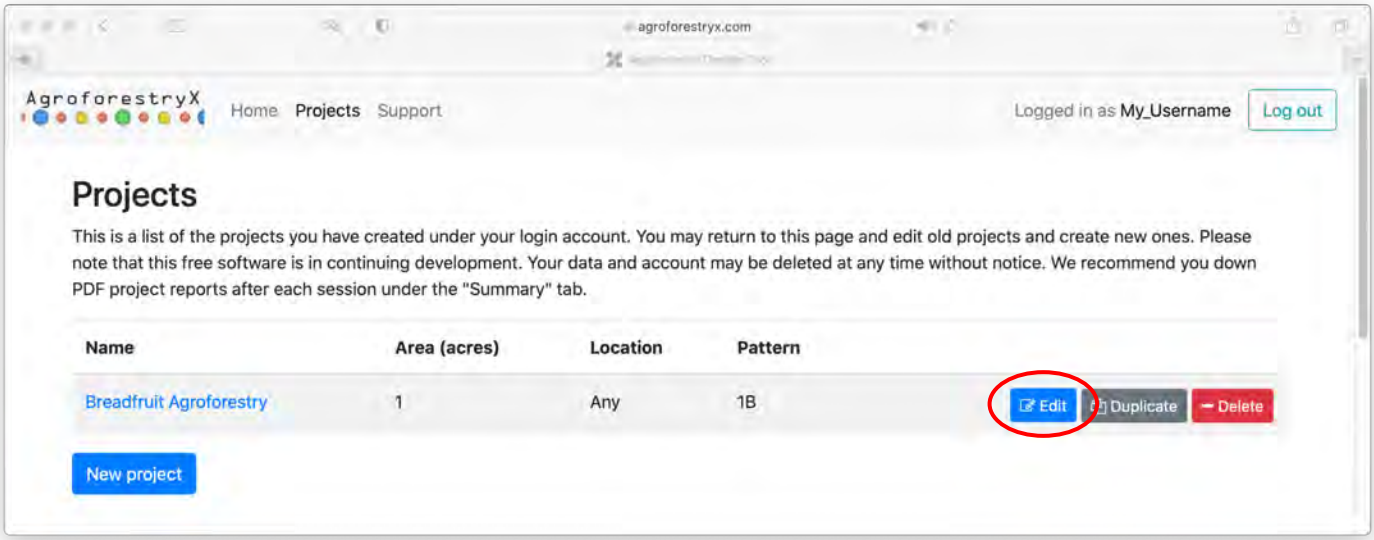
Figure 11: Creating a project by duplicating an existing project.

5.2 How many projects can I create?

There is currently no limit.

5.3 How do I edit an existing project?

In the project page click on the name of a project or select the edit button to edit the existing project. A project may also be deleted by selecting the “Delete” button.



6 Project details

Each new project has a unique set of environmental and other characteristics that need be input into the ADT (Figure 12). For each project, location and certain environmental conditions are entered to aid in species selection (Figure 13). Google Earth is useful to determine average rainfall, elevation, and area of your project. This information can also be obtained via almanac, maps, and by measuring the perimeter of the project on the ground.

6.1 What geographic region is this tool used for?

This tool was developed for all U.S. affiliated Pacific islands.

6.2 Can it be used for any region?

Many of the species in the dataset are common to agroforestry throughout tropical and subtropical regions. If your location falls outside of the ones listed, select "Any" from the drop-down menu.

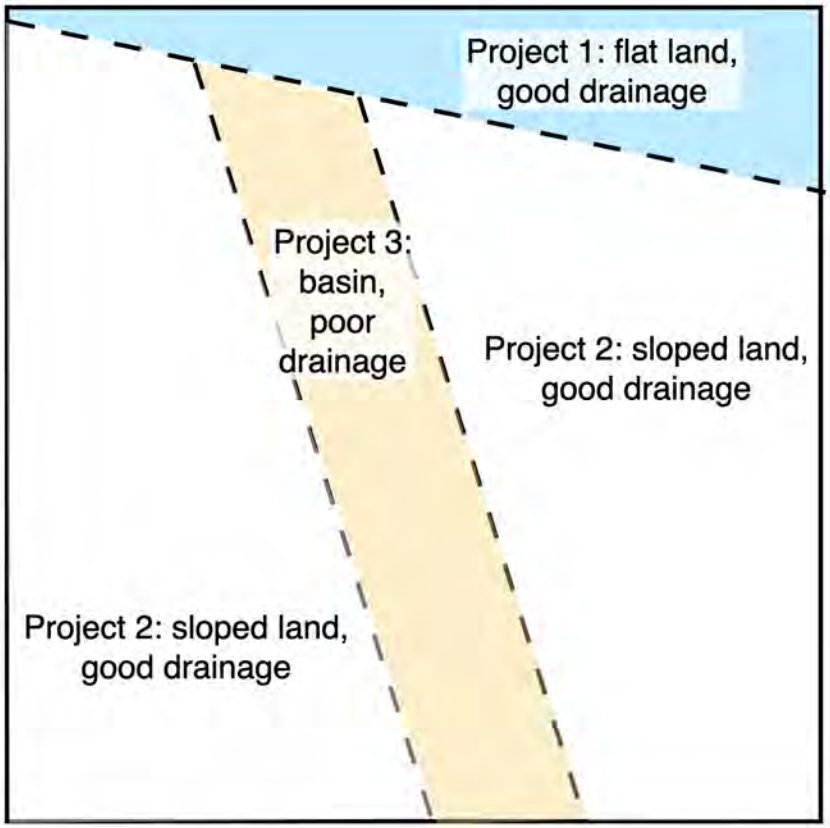


Figure 12: Each area with uniform conditions should be treated as a separate project in order to select species appropriate to the site conditions.

6.3 Are there minimum and maximum values for rainfall and elevation?

The dataset covers 30–160+ inches (760–4060 cm) of annual rainfall and generally covers from sea level to 5000+ feet (1520 meters), depending on location.

6.4 Are there minimum and maximum values for project size covered by this tool?

The minimum project size is 0.25 acre (0.1 hectare). There is no maximum project size.

6.5 What happens if I select “No restrictions” for the standards compliance checker?

Selecting “No restrictions” releases the project from conforming to any particular standard.

6.6 Can I use this tool to design agroforestry systems that meet the NRCS requirements for their cost share programs?

Yes, if within the USDA NRCS Pacific Islands Area (NRCS PIA) and it is approved by the NRCS personnel you are working with. By selecting “Assist with NRCS standard compliance,” the tool will assist you through the rest of the process to meet some of the standards. For further information, please see: USDA NRCS. Forestry/Agroforestry Technical Note No. 11: Mixed Agroforest Specification; USDA NRCS Pacific Islands Area: Honolulu, HI, USA, 2017. For additional information on this standard, it is stored online in the following location: NRCS Field Office Technical Guide (FOTG) > Hawaii/Pacific Island Area > Section IV > Conservation Practice Standards and Support Documents or request more information from your local Pacific Island USDA NRCS office.

6.7 Can I use this tool to plan agroforestry systems that meet the regenerative standards suggested by Elevitch et al. 2018?

Yes, by selecting the “Assist with regenerative standard compliance (checks for minimum species diversity)” the tool will guide you throughout the rest of the process to meet these standards. For further information on the regenerative standard, please see Elevitch, Craig, D. Mazaroli, and Diane Ragone. 2018. “Agroforestry Standards for Regenerative Agriculture.” Sustainability 10 (9): 3337. https://doi.org/10.3390/su10093337.

6.8 What happens when I click “Proceed.”

Upon clicking “Proceed,” the project parameters are saved so they can be used to query the dataset and produce a list of recommended species on a subsequent page. The parameters in a pre-existing project can be altered later, if desired.

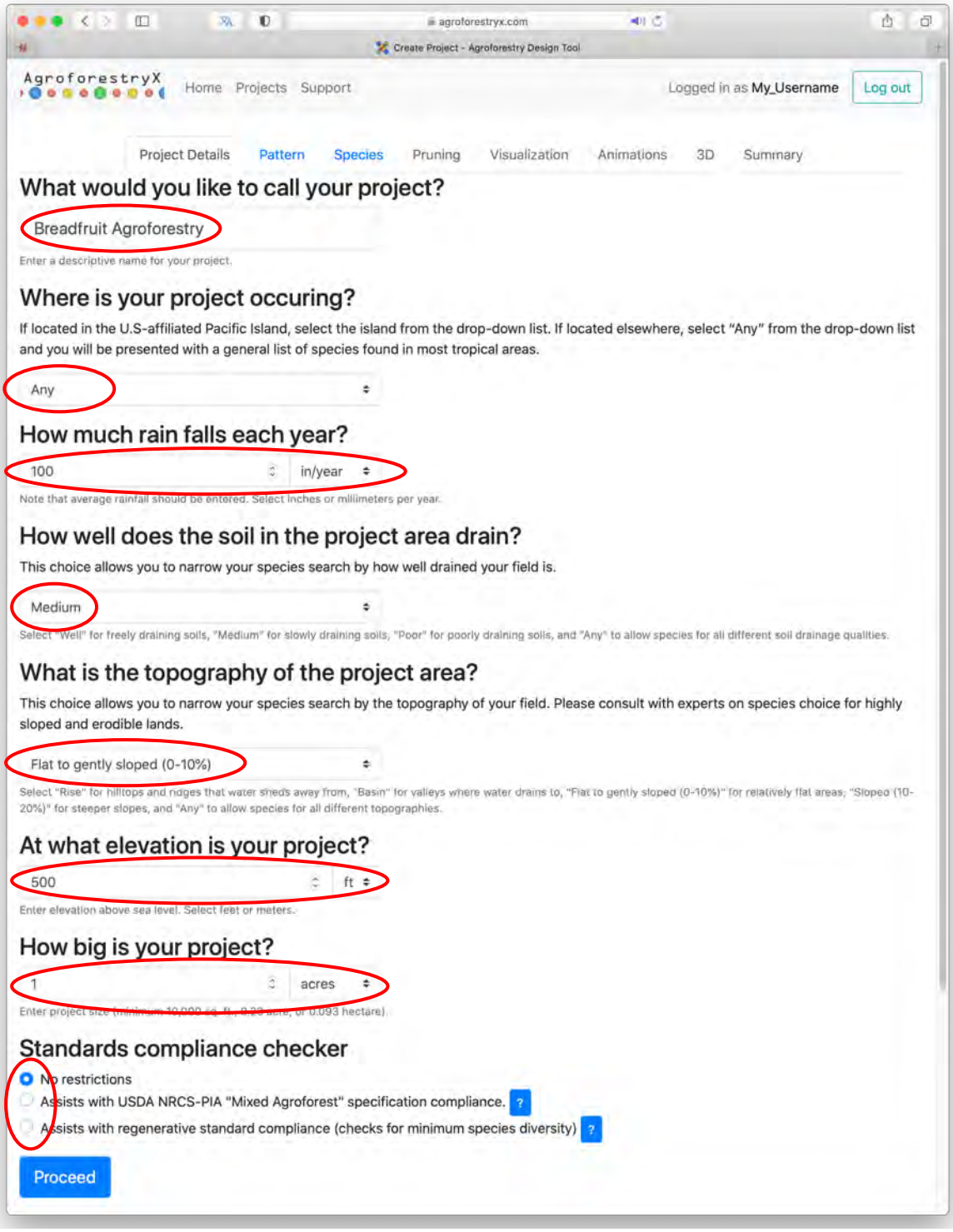


Figure 13: Project details that need to be entered.

7 Pattern selection

The tool provides several patterns from which to select (Figure 14). The spatial planting layout patterns measure 100 ft x 100 ft (30.5 m x 30.5 m). Each is designed with a unique theme in mind. To the right of each pattern illustration is a summary table with layers and within-row and between-row spacing, along with total plant counts for each layer. Plants of each layer are color coded. Select a pattern that is best suited to the desired project outcome, then click the button at the bottom of the page "Proceed with template." The selected project pattern printed in the final report is used to guide installation.

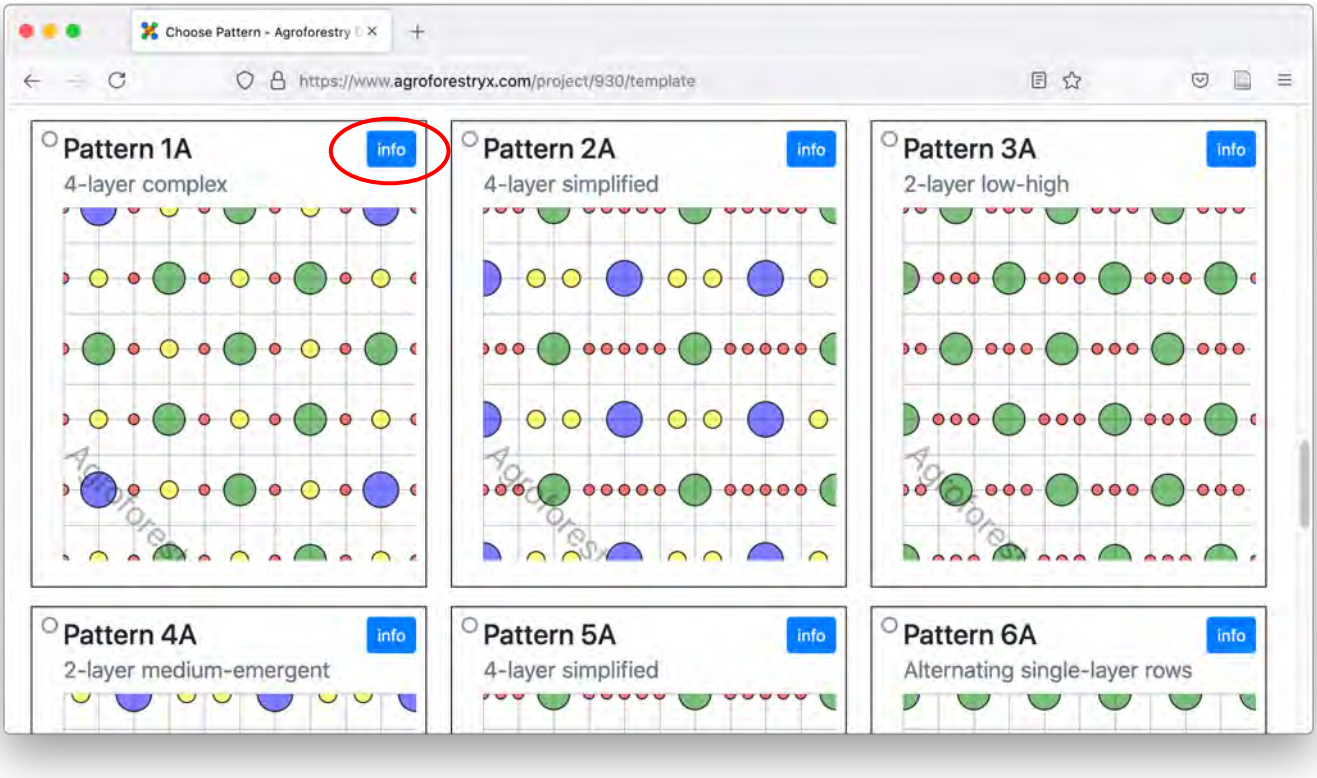


Figure 14: Planting patterns available for selection.

7.1 I'm trying to go to the pattern page but it won't open. What do I do?

You must fill in all required fields and press the "Proceed" button in all previous steps in order to go to the next step in the design process. Only links along the top navigation bar colored blue are active links.

7.2 I'm having trouble deciding which pattern to choose. Is there more information available for each pattern?

Next to the name of each pattern is a blue 'info' button. Click it and a new window will open with more details about the pattern (Figure 15).

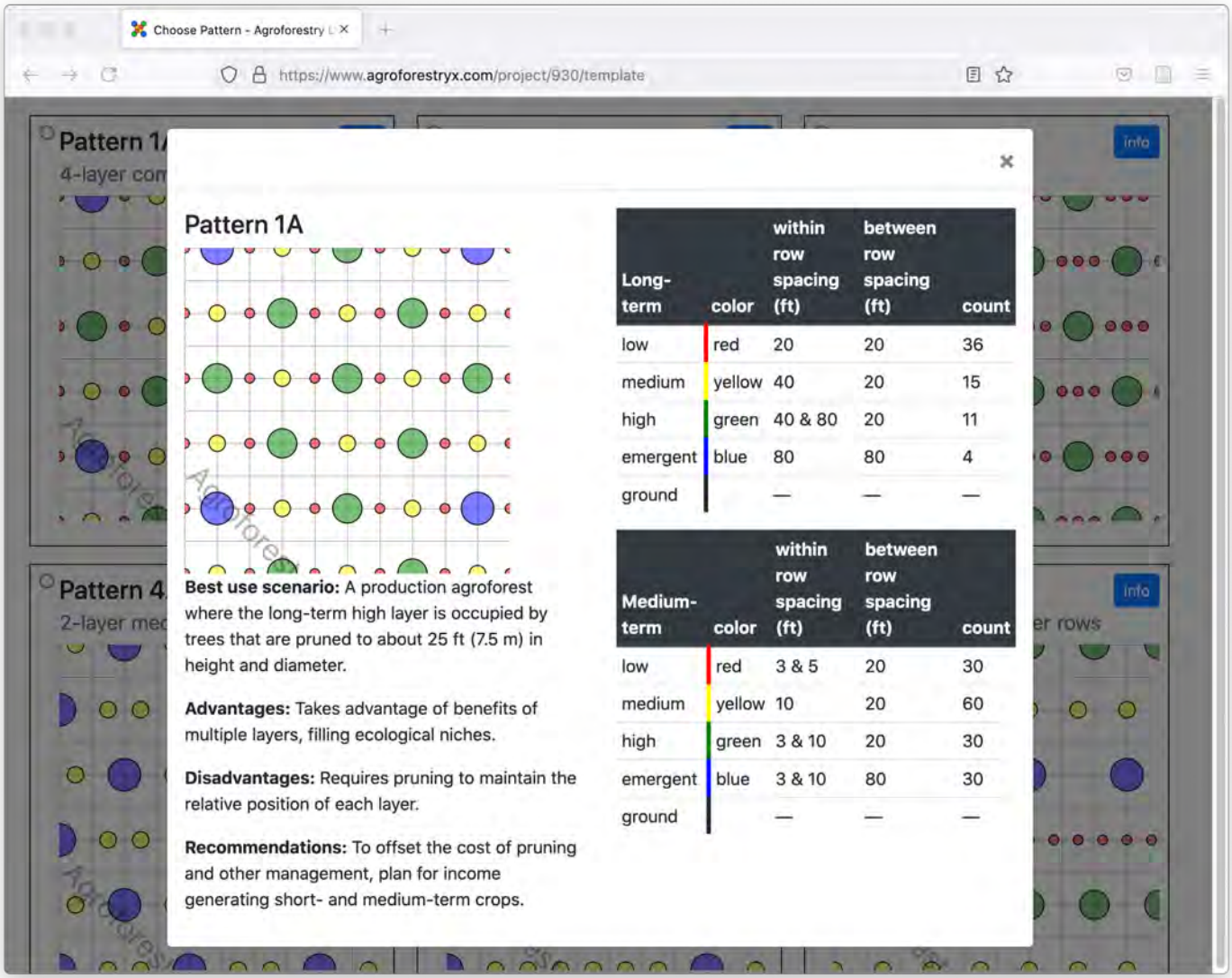


Figure 15: Each pattern has additional information that can be accessed by clicking its Info button.

7.3 I don't see a pattern that fits my goals. Are there more to choose from?

This free version is limited in the number of patterns available. Contact the tool creators for customized options.

7.4 Can I change the path width to another length?

The tool currently offers 15 ft and 20 ft path widths for each pattern (Figure 16). Contact the tool creators for customized options.

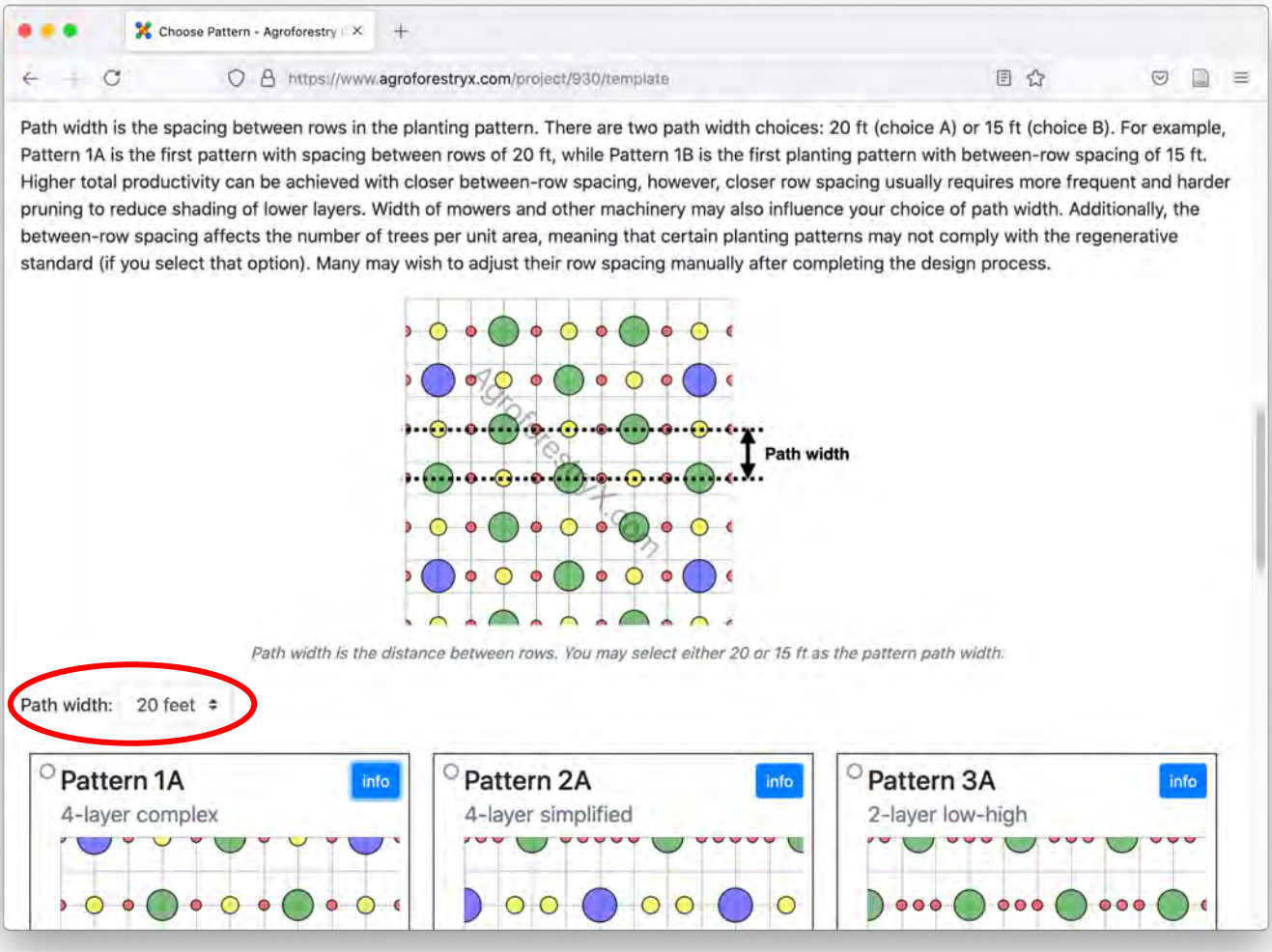


Figure 16: Path widths of 15 ft or 20 ft may be chosen for each pattern.

7.5 Which pattern can I use to meet USDA NRCS standards?

When you choose the option for assistance to meet the USDA NRCS specification, only patterns that qualify are presented to you as an option.

7.6 Which pattern can I use to meet regenerative standards?

If you select this option, then you will only be presented with pattern choices that meet the regenerative standards.

7.7 I'm trying to select the species selection page, but it won't open. What do I do?

After selecting your path width and pattern, be sure to click the 'Proceed' button below the patterns to go to the next step (Figure 17).

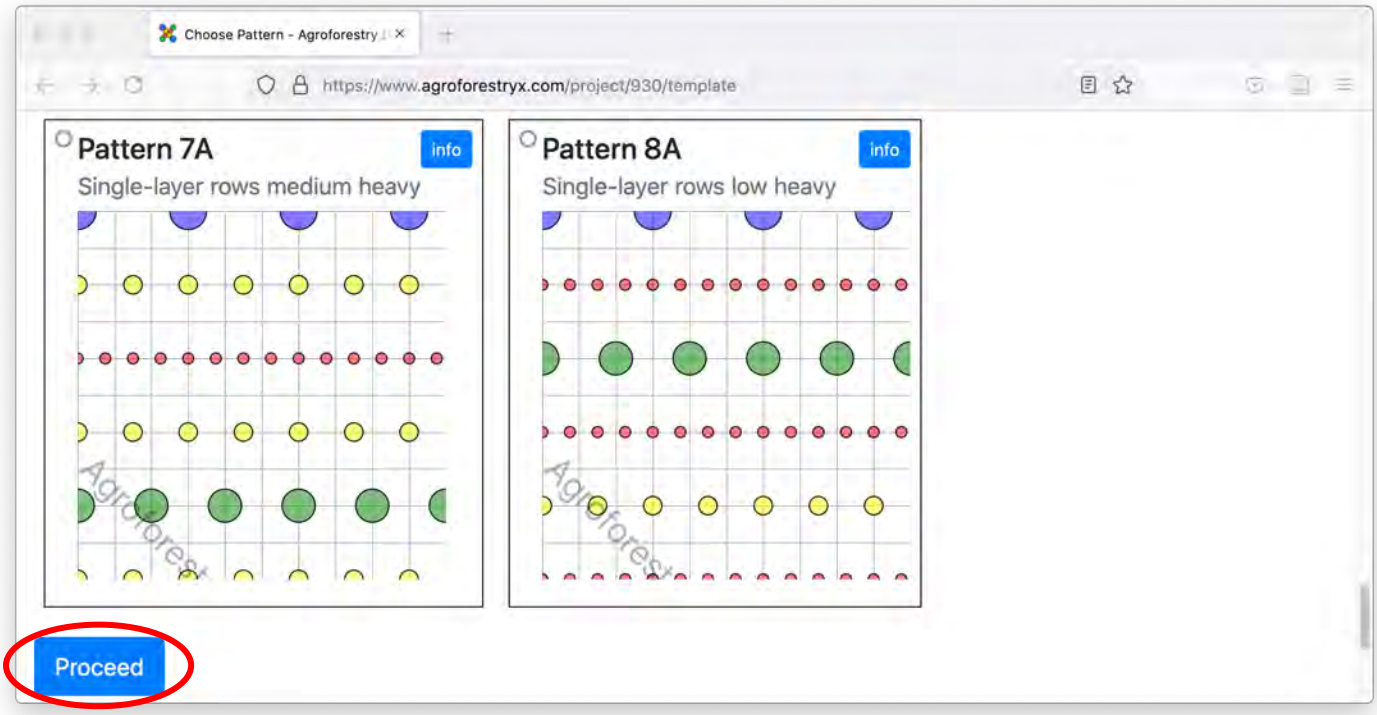


Figure 17: Click on the Proceed button to move to species selection.

8 Species selection

A list of species based on the project details and chosen template is displayed. The list is organized into tables for each canopy layer within the long and medium time periods. Each table has eight columns with information about each species. First select from the list of long-term species. A minimum of one species for each stratum from each time period must be selected before proceeding to the next step. Projects seeking to conform to either of the other standards will be subject to their own unique set of restrictions.

Users are encouraged to select several species for each available canopy layer and time period. However, caution is advised when creating overly diverse systems, as these can be very complex to manage, requiring expert knowledge and experience. The template selected will determine the numbers of individual slots available for each layer/time period. Diversity of species and numbers of individuals will need to be balanced according to the number of available slots for their respective layer/time period. On the next page after selecting species, you can alter the numbers of individuals for each species selected.

8.1 How many species can I select?

Maximum diversity for any given layer/time period is based on the number of available slots for the selected pattern for a given project (Figure 18). The number may vary depending on which standard was selected on the project details page.

8.2 How many species do I have to select?

A minimum of one species must be selected for each term/stratum required by the selected pattern for a given project. The maximum number (Figure 18) varies depending on which standard was selected on the project details page.

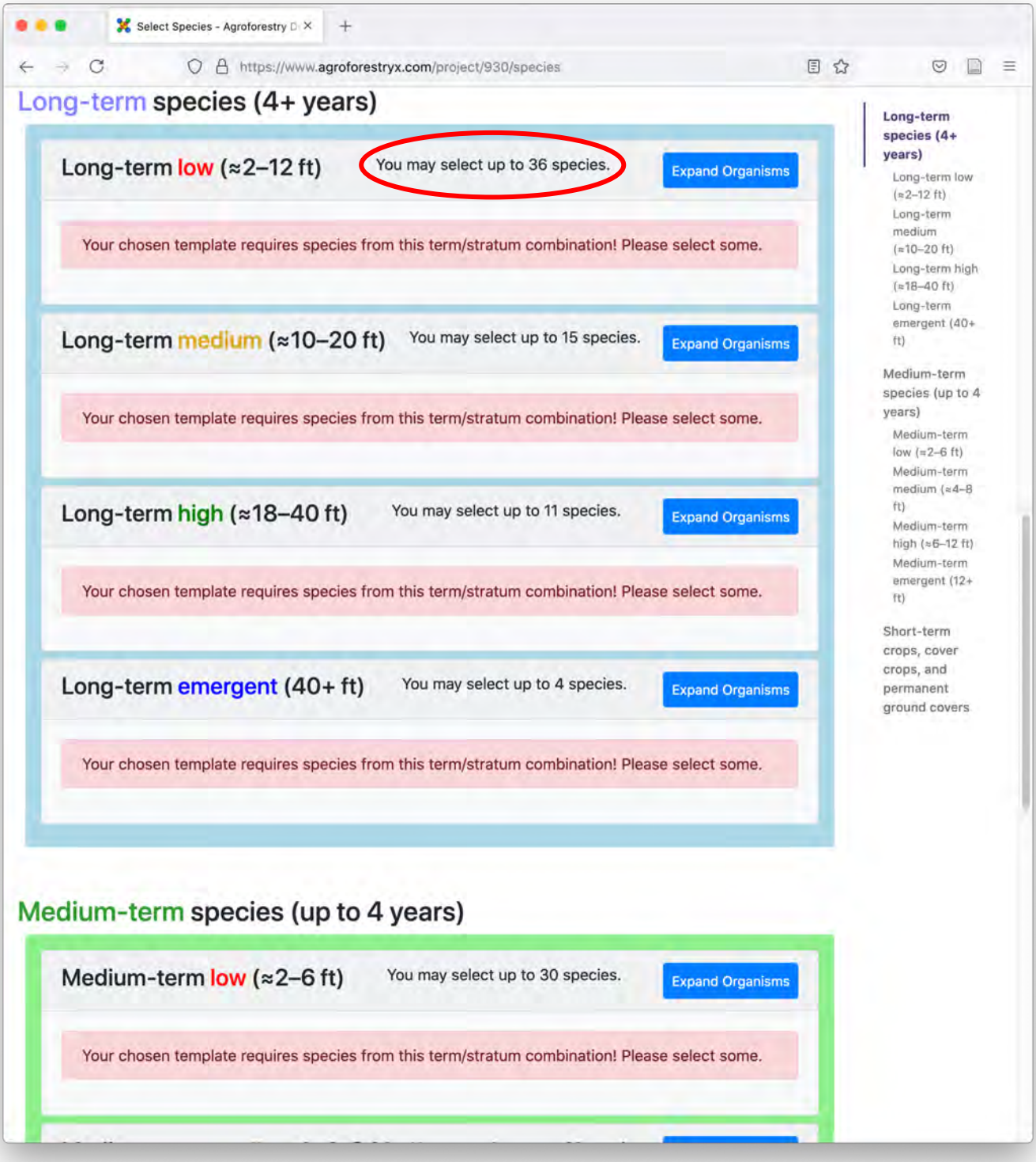


Figure 18: The maximum number of species per canopy layer and time period is noted in the species selection box.

8.3 I'm looking for a certain species. Is there a quick way for me to find it?

Located above the Long-term species lists is a drop-down menu labeled with the number of species already selected (Figure 19).

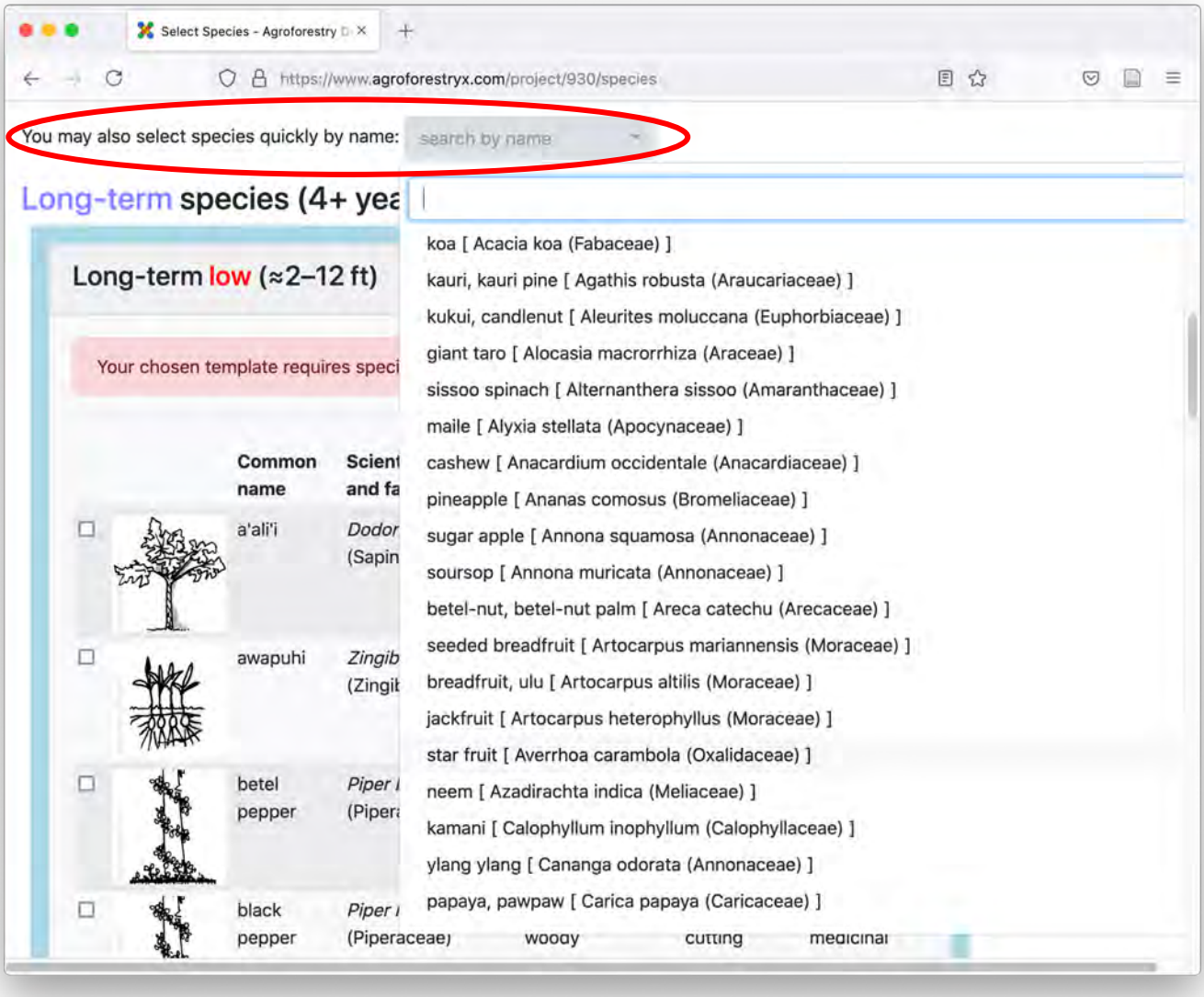


Figure 19: There is a drop-down menu above the long-term species list that allows searching for desired species and quick selection.

8.4 I don't see a species I want.

Each list for layers and time periods has optional species labeled "your choice of species" (Figure 20). These may be selected anytime a particular species is desired but not present in the dataset.

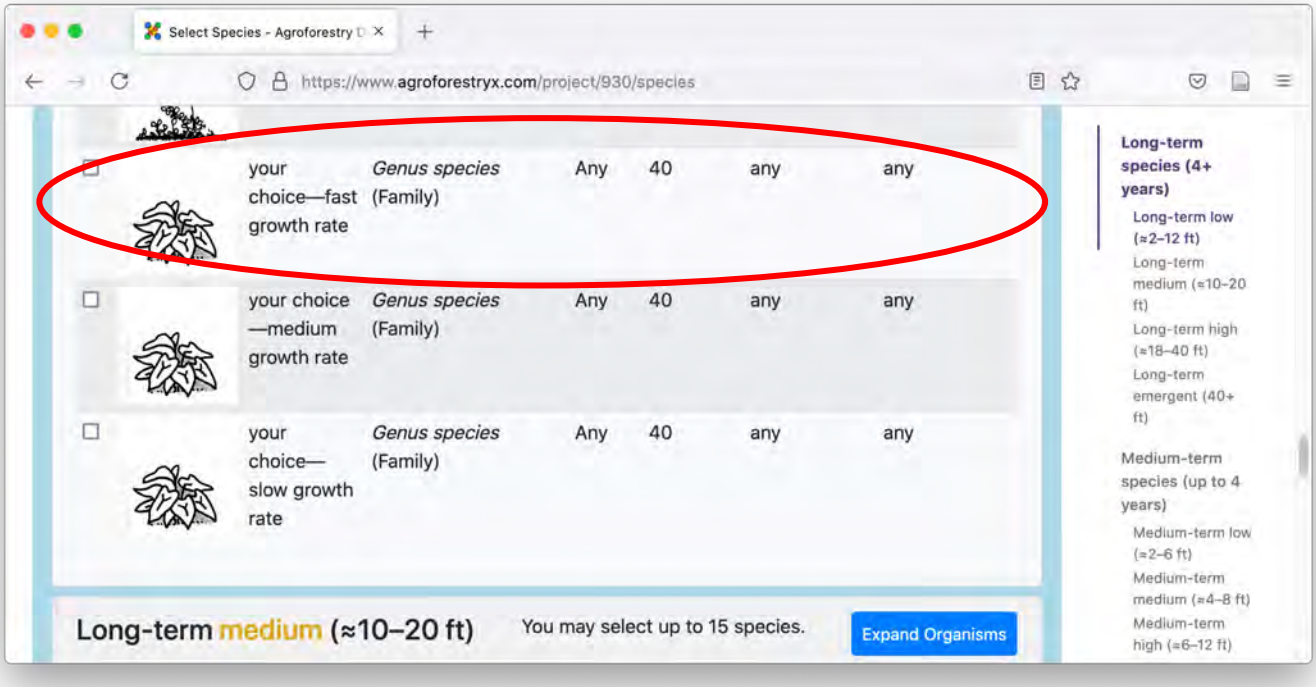


Figure 20: Each layer and time period have "wildcard" species with fast, medium, and slow growth rates in case you would like to use species that are not found in the list.

8.5 Where are the short-term crops and when will I be able to choose some?

You do not have the option of selecting short-term plants on the species selection page. A list of short-term crops will be given at the bottom of the summary page for your consideration.

8.6 I've selected my species. Why won't the pruning page open?

When the correct number of species have been selected for your project click the "Proceed" button at the bottom of the page to go to the next step. When a standard has been selected the user will be prompted with boxes at the top of the species selection page with instructions and will not be allowed to proceed until all requirements are met (Figure 22).

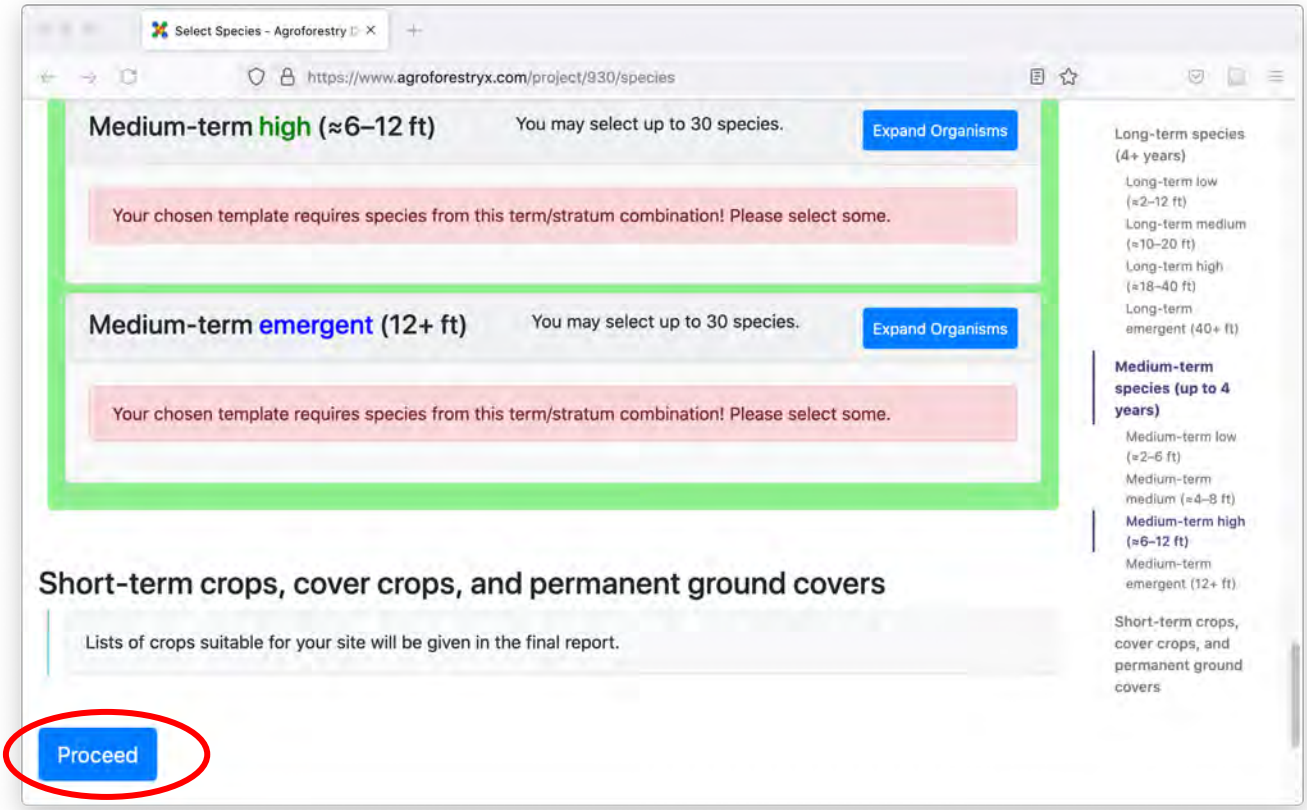


Figure 21: After selecting species, click the Proceed button to move to the next step.

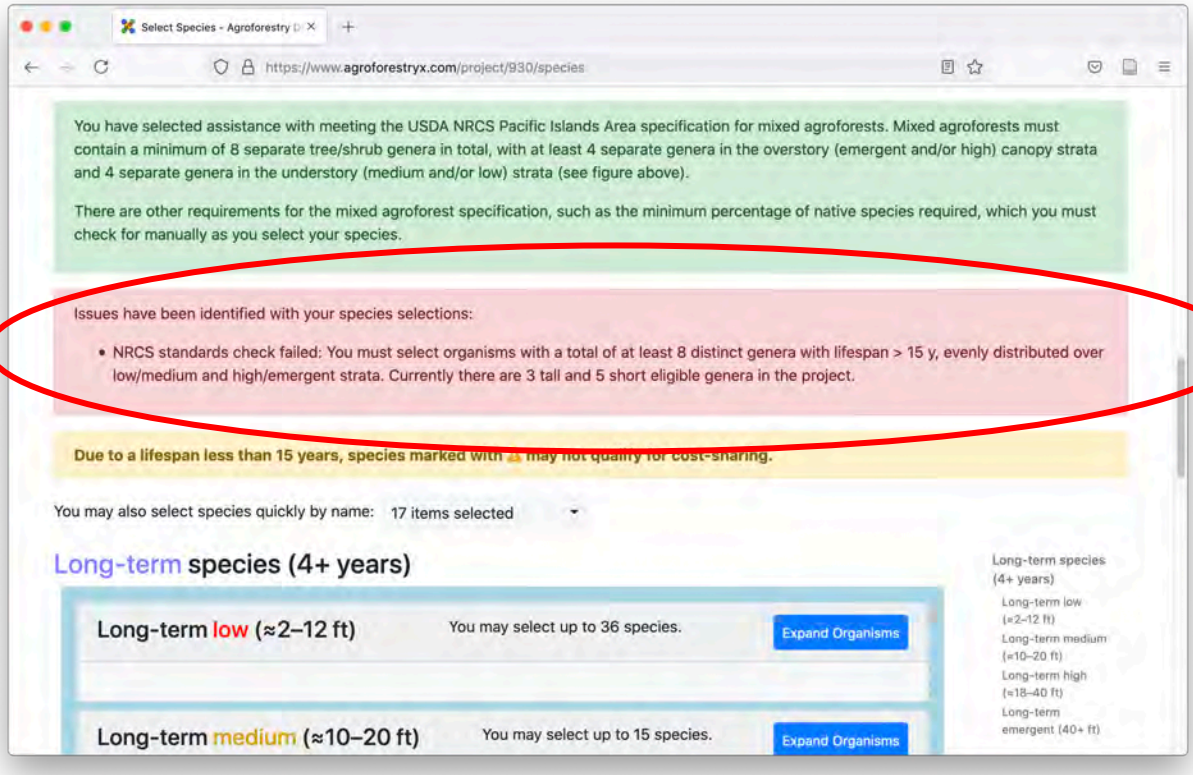


Figure 22: Guidance for species selection for the NRCS specification is given at the top of the page.

9 Pruning sizes and species counts

The species selected in the previous step (on the Species Selection page) are displayed in tables organized by time period and stratum with management information about each species.

Six columns contain dynamic fields automatically primed with default values that can be altered by the user. “Prune at height (feet)” and “Prune at diameter (feet)” are the desired canopy height and diameter (respectively) before pruning. “Post-prune height (feet)” and “Post-prune diameter (feet)” are the desired canopy height and diameter (respectively) after pruning (Figure 23).

The column labelled “# per 100ft x 100ft” is the number of individual slots available for each stratum in the project template area. When this number is adjusted each member of a time period/stratum will update, in keeping with the total number of individuals allowed for each slot. When too many individuals are selected a red error message will appear to prompt the user to select fewer individuals. The same is true for not selecting enough individuals.

The first column labelled “Productive Lifespan” allows you to alter the length of time a plant will be present in the system.

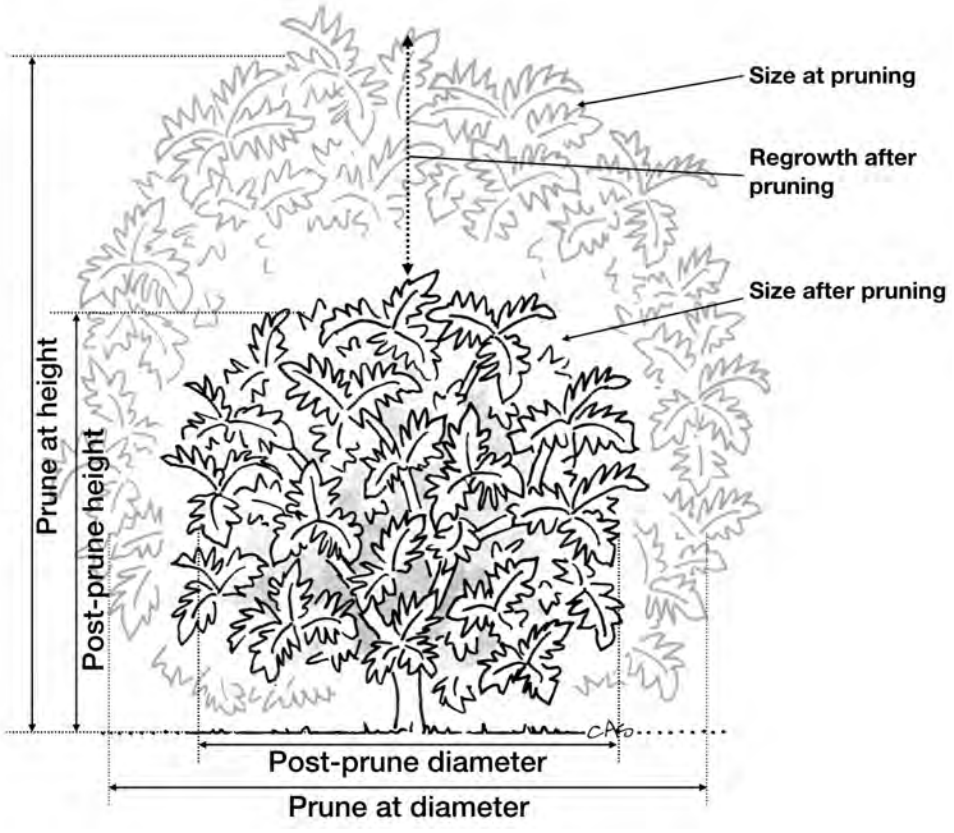


Figure 23: Guidance on pruning size parameters.

9.1 Do I have to change the pruning sizes?

Pruning variables have been pre-set to nominal values for each species. It is not required to alter them. However, depending on the combinations of species selected for each term/stratum it may be desirable or even necessary to adjust pruning variables to resolve potential conflicts. When you modify a default pruning value, the cell background turns orange to indicate there's been a change.

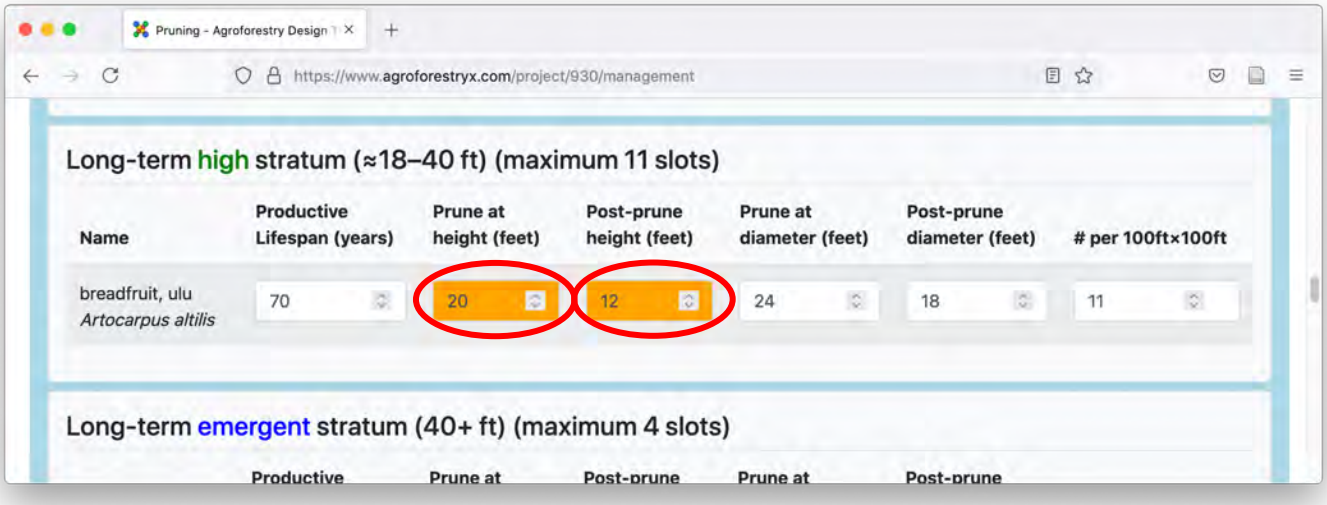


Figure 24: When you change a default pruning variable, the cell background turns orange to indicate the change.

9.2 I changed a number and the cell background turned red.

When you change a default value to a number that is invalid or erroneous, that cell turns red (Figure 25). Please adjust the value a to feasible number.

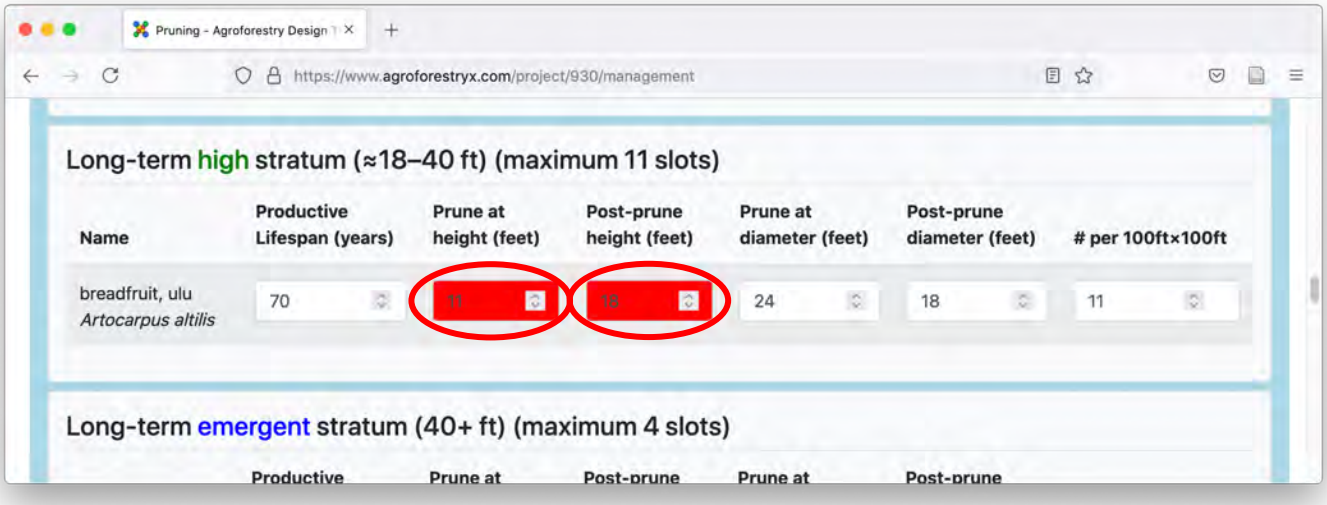


Figure 25: When you change a number to an invalid or erroneous value, the cell turns red. In this case the post-pruning height was set to be greater than the prune-at height.

9.3 I want to have less of a certain species but when I try the number of individuals box turns red. What do I do?

If there is only one species for a category selected, the number of individuals for that species will be dictated by the number of slots available based on the selected pattern. All slots of any pattern must be filled. Selecting additional species will resolve the issue by allowing a more flexible design.

9.4 Can I force something into another stratum through pruning?

No. Doing so will cause conflicts in time and space. The tool has been specially designed to avoid such scenarios by flagging such manual adjustments as an error (Figure 26).

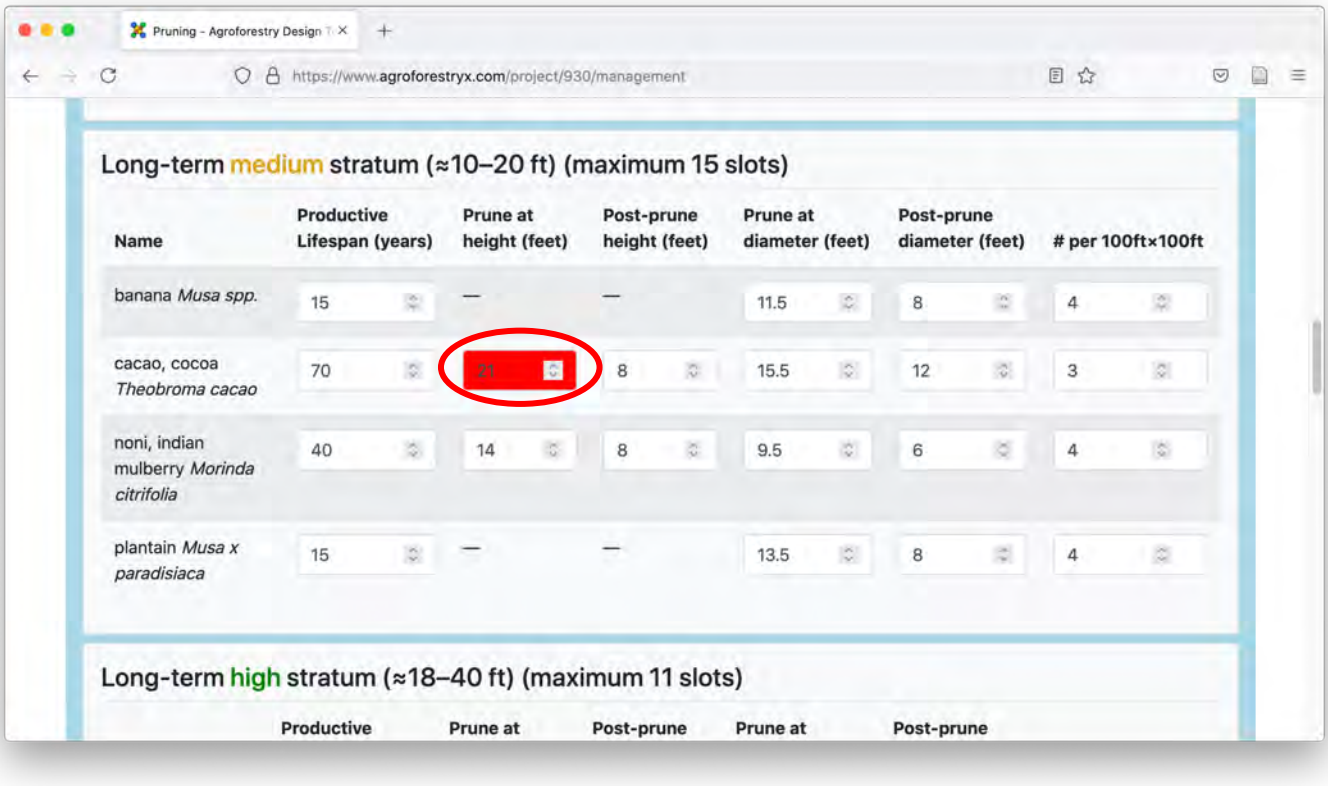


Figure 26: Adjusting pruning height outside the range of its stratum is flagged as an error to avoid conflicts between layers.

9.5 I want to visualize my project, but the page won't open. What do I do?

Once all pruning variables have been confirmed and there are no errors, go to the next step by clicking the "Proceed" button at the bottom of the page (Figure 27).

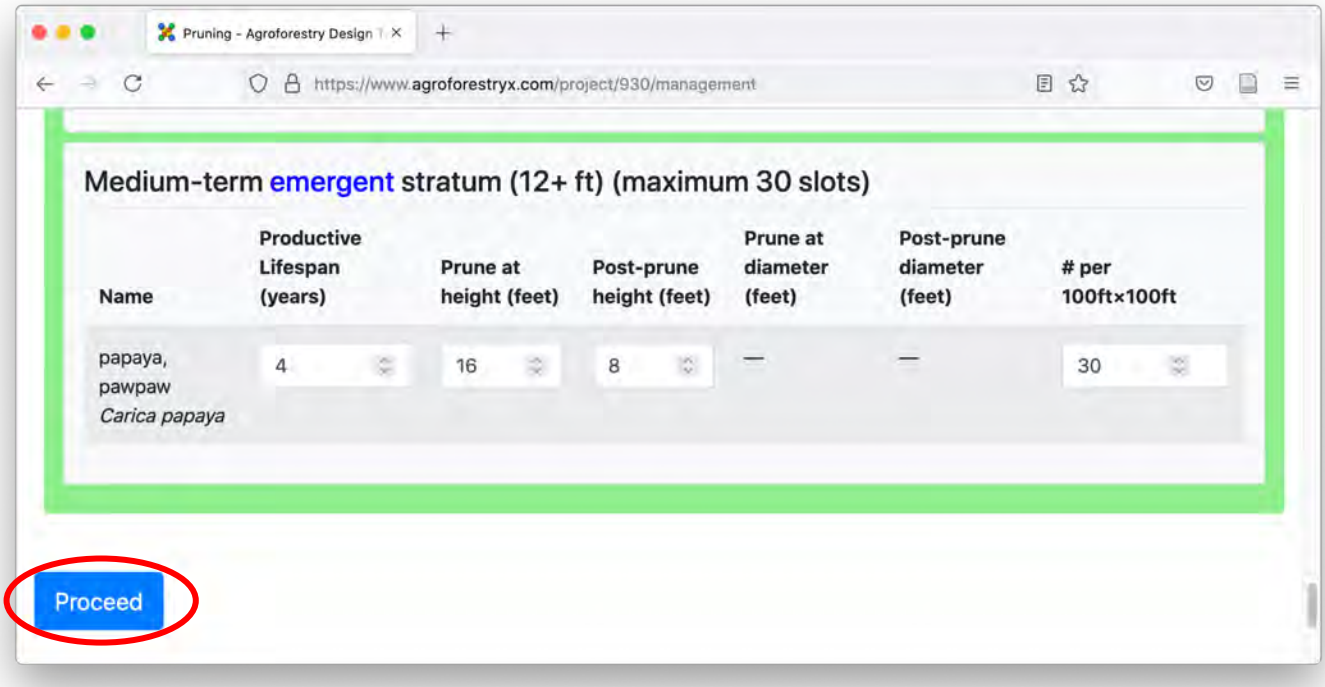


Figure 27: You must eliminate any errors flagged in red and click proceed at the bottom of the page in order to move to the next step.

10 Visualization

The Visualization page displays how the agroforest you have designed on previous pages is estimated to look over a period of years. Overhead views are displayed for both medium and long terms at three stages of development: initial planting, 3-year, and 10-year. Blue-colored tabs located above the summary table for each template indicate each of these three stages of development. Side views are also displayed for Years 3 and 10. The summary tables above each template reflect changes in the management variables.

In the overhead view, the diameter of each colored circle is reflective of the estimated diameter of each species, according to the management variables selected in the previous step. Clicking on a tab reveals a snapshot in time of the canopy development. These are used to help visualize conflicts with regards to numbers of individuals of different species and their respective pruning height and diameter. If desired, the user may hit the back button on their browser to return to the previous page. Returning to the Pruning page allows you to adjust species parameters according to what was learned via the visualization, and then return to the Visualization page to inspect the changes. Once confident the conflicts have been resolved, the user now proceeds to the next step.

Note, short-term species are not visualized with this tool. A list of species and the necessary data for integrating with the project will be displayed in the Summary page.

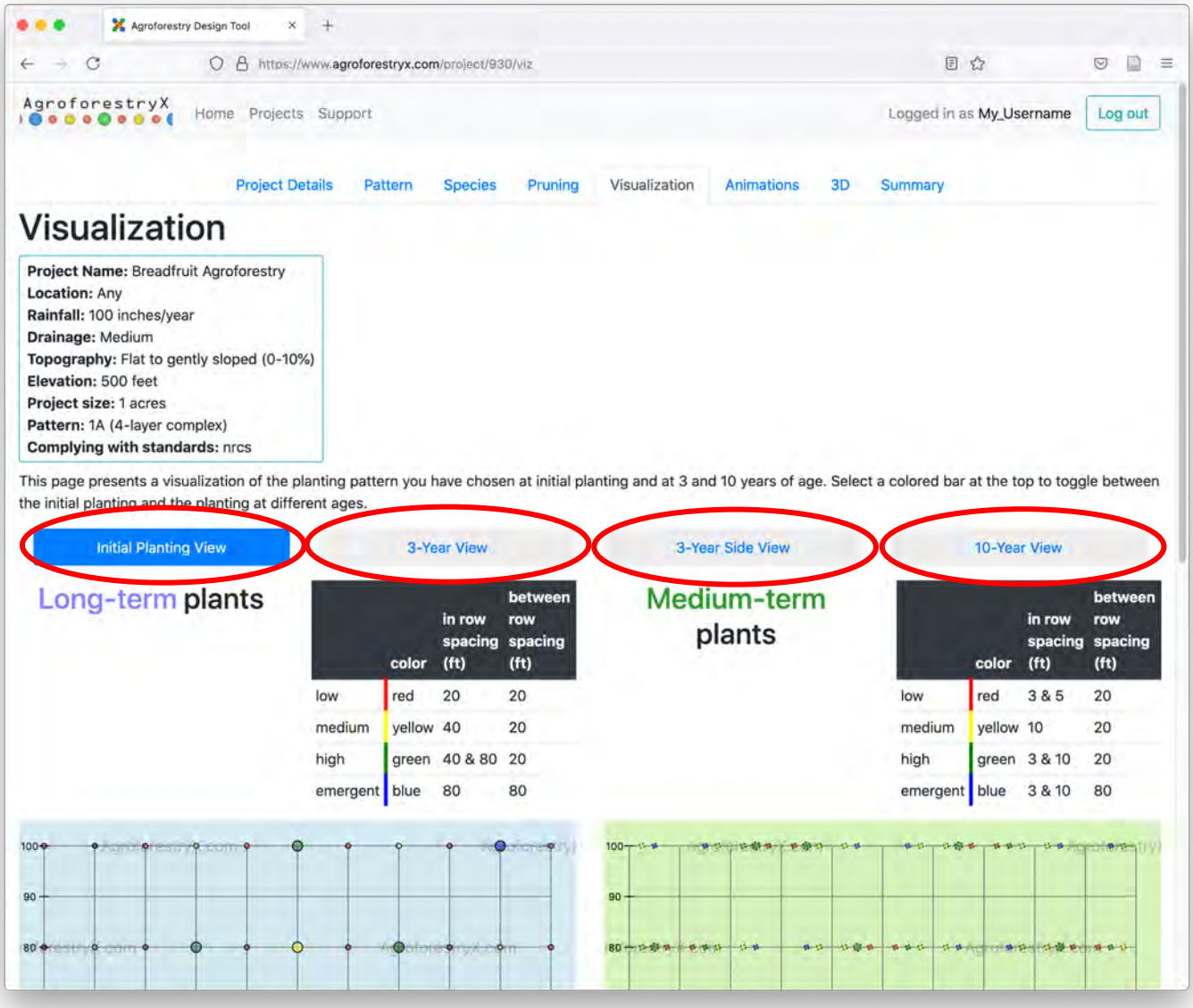


Figure 28: Four visualization views are given in the visualization page.

10.1 How do I know which species are represented in the planting views?

By placing your cursor over the circles in the views, the name of each species assigned to that position will pop up above it.

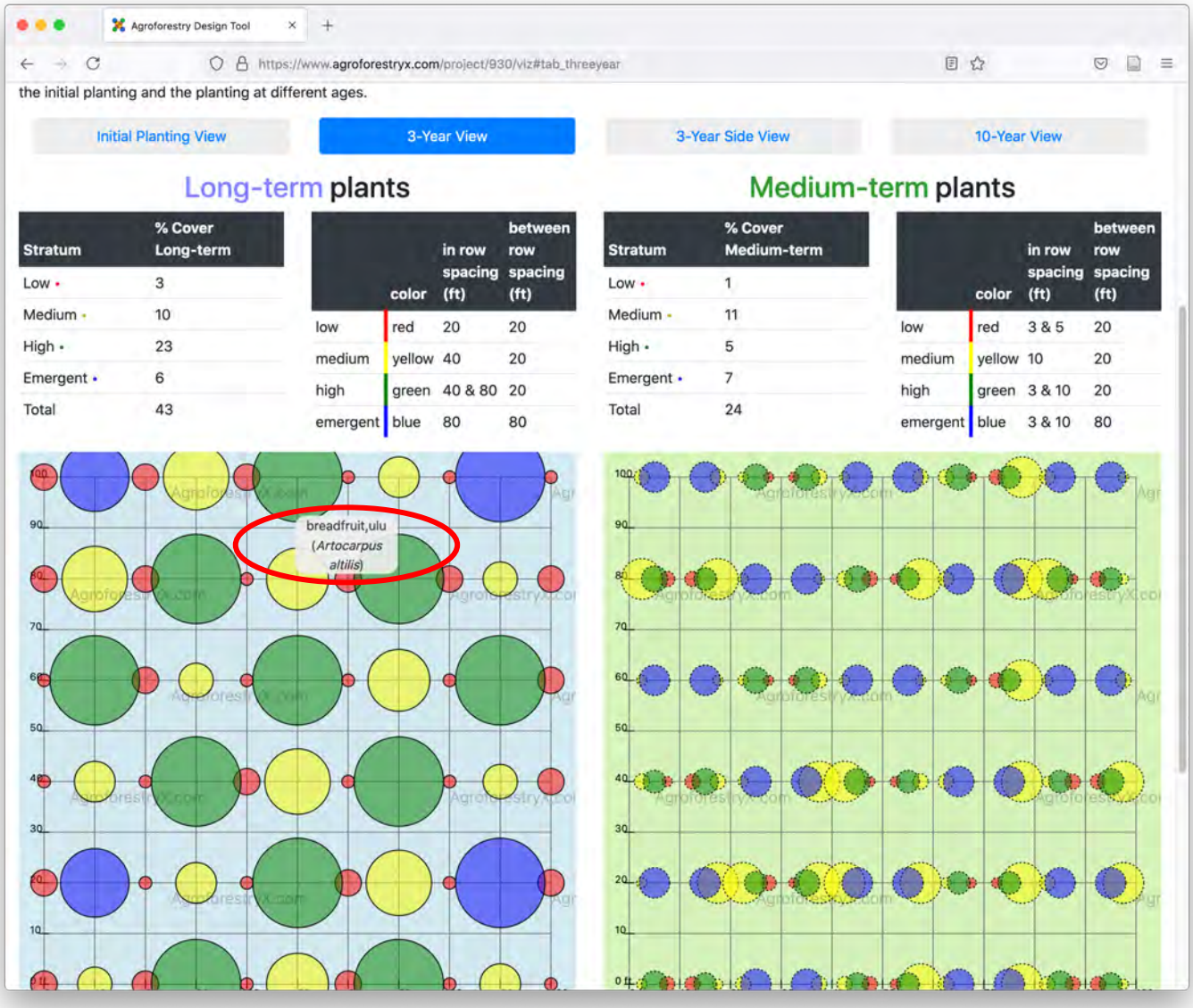


Figure 29: Hovering the cursor over the colored circles reveals the plant names.

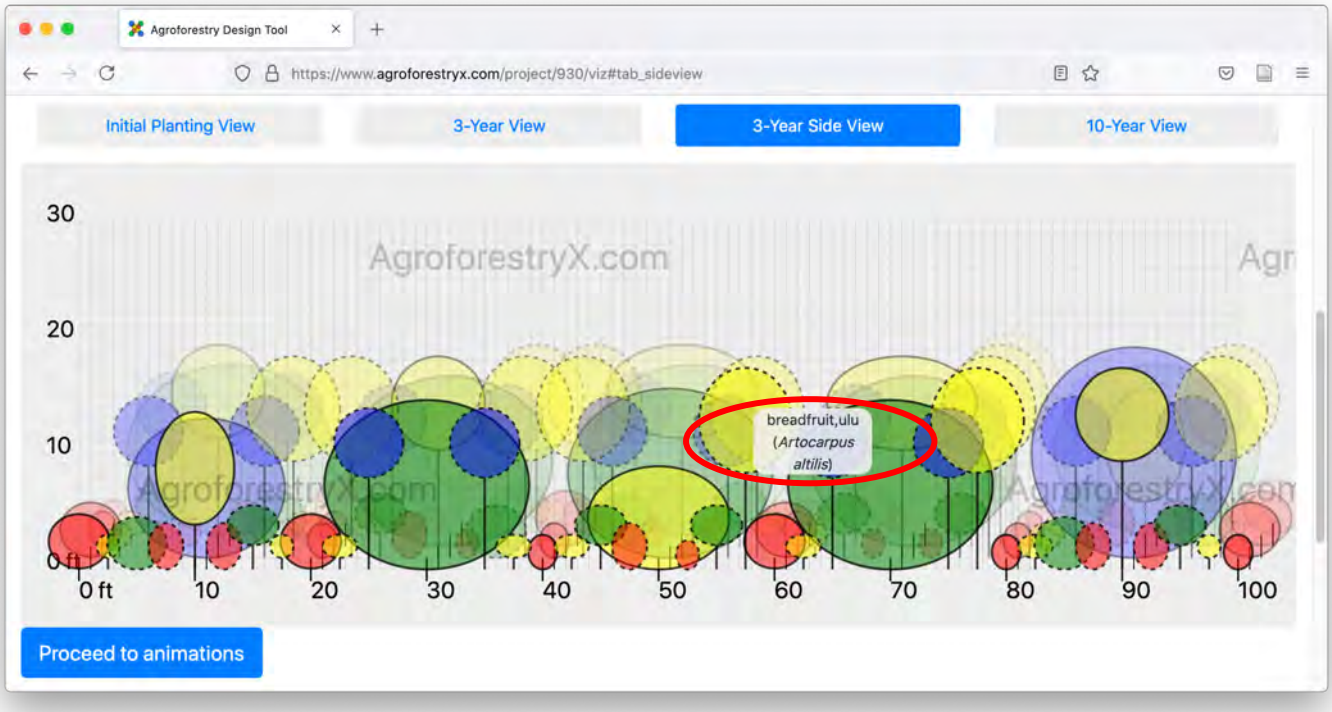


Figure 30: Hovering the cursor over the colored circles reveals the plant names.

10.2 What is "% Cover"?

The "% Cover" column (Figure 31) is the amount of project area covered by the collective canopies of all species in their respective term/stratum and selected pattern. Ideally, 100% of the project area is covered 100% of the time.

10.3 Where are the short-term plants?

Due to the visual complexity of placing so many individual short-term plants together with long- and medium-term plants, rather than illustrating the short-term plants, the tool gives a table of short-term species with planting details such as seeding rates, spacing and time to harvest in the Summary.

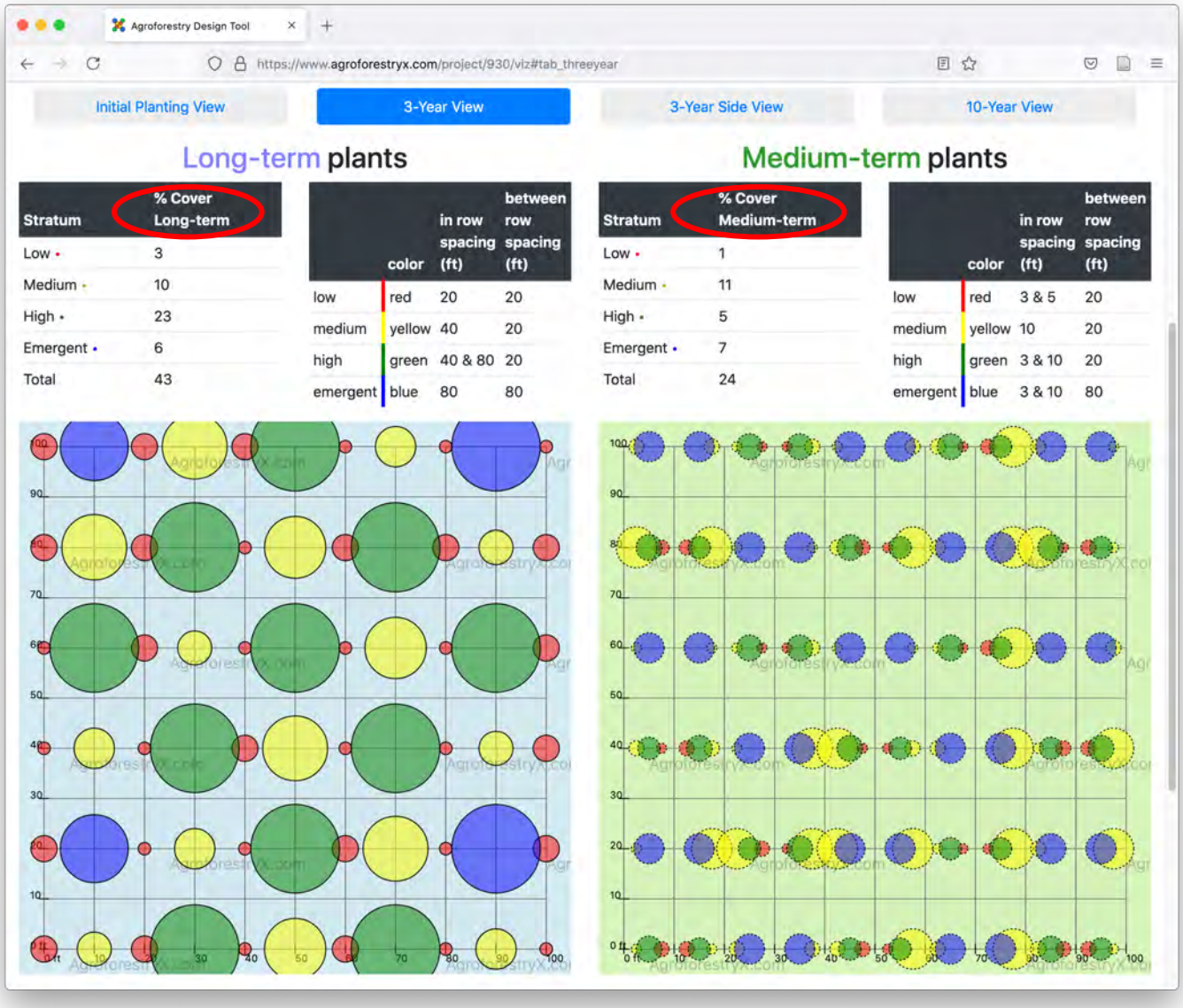


Figure 31: The % Cover column gives an estimate of the canopy cover of the different layers over time.

10.4 Can I change the placement of individual species in the project?

Not directly. Species are placed on a view pattern randomly. Each time the visualization page is refreshed, the species are placed in a new random order. The placement seen in the visualization is reflected in the animations and summary. If a different placement is desired go back to the visualization page and refresh it until the desired placement is displayed. If only one species is selected for a stratum/term, then no change in position will occur. Once you have completed your design, you will be responsible for placing respective species in the planting pattern.

11 Animations

The animations page displays both overhead and side views together with a time slider beneath. Once the page loads, the animations begin at time 0. The animations proceed at a rate of one year per second. The user may move the animations forward and backward in time by pointing and sliding the time indicator button to the desired position in time. By pointing and clicking a point in time, the user can repeat a portion of the animation as many times as desired. When reviewing the visualization, conflicts maybe observed that require fine-tuning. In that case, return to the management variables page (Pruning) to make the necessary adjustments. When satisfied the project design meets all required specifications proceed to the summary page.

11.1 Can I slow down the animations?

The animations can be paused, restarted, or replayed at any time using the controls below the animation (Figure 32).

Figure 32: Animations can be stopped, restarted, and replayed at any time.

11.2 Can I stop or reverse the animations?

While pointing to the slider button and holding the mouse button down it is possible to pull the animation forward and back in time or even hold in a stationary temporal position (Figure 32). This allows the user to study the animation as needed.

11.3 I notice some of the canopies of species from the same time period and stratum are overlapping. Is there anything I can do to stop it from happening?

Overlapping canopies (Figure 33) of species of the same term/stratum represent conflicts, which may be resolved via pruning. Return to the Pruning page and adjust the canopy diameter variables. Adjusting variables and returning to the animations page to review the outcome may be necessary before all conflicts in the system are resolved for the 15-year time period.

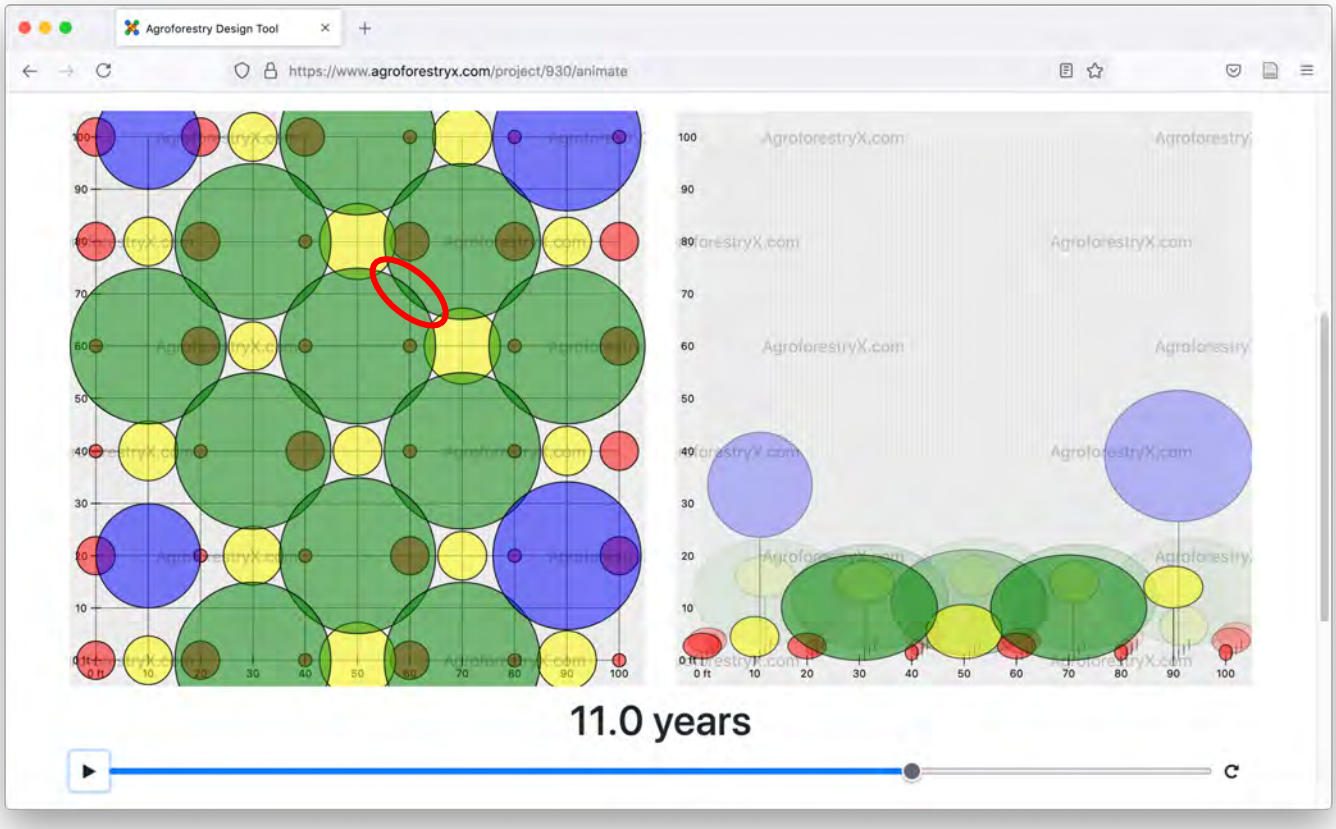


Figure 33: Overlapping canopies of plants in the same strata suggest that the pruning variables should be revised.

11.4 Many of the species look crowded to me. What can I do?

Adjust the canopy diameters through pruning as outlined above in the “Pruning sizes and species counts” section or select fewer and/or different species.

12 3D animation

On this page, one can view a three-dimensional animation of the agroforest growth over 15 years (Figure 34). One can stop or move the animation forward and reverse in time by click and dragging the time slider. The rotation of the animation can be stopped and or rotated into a new stationary position by clicking and releasing or holding and shifting positions on the animation.

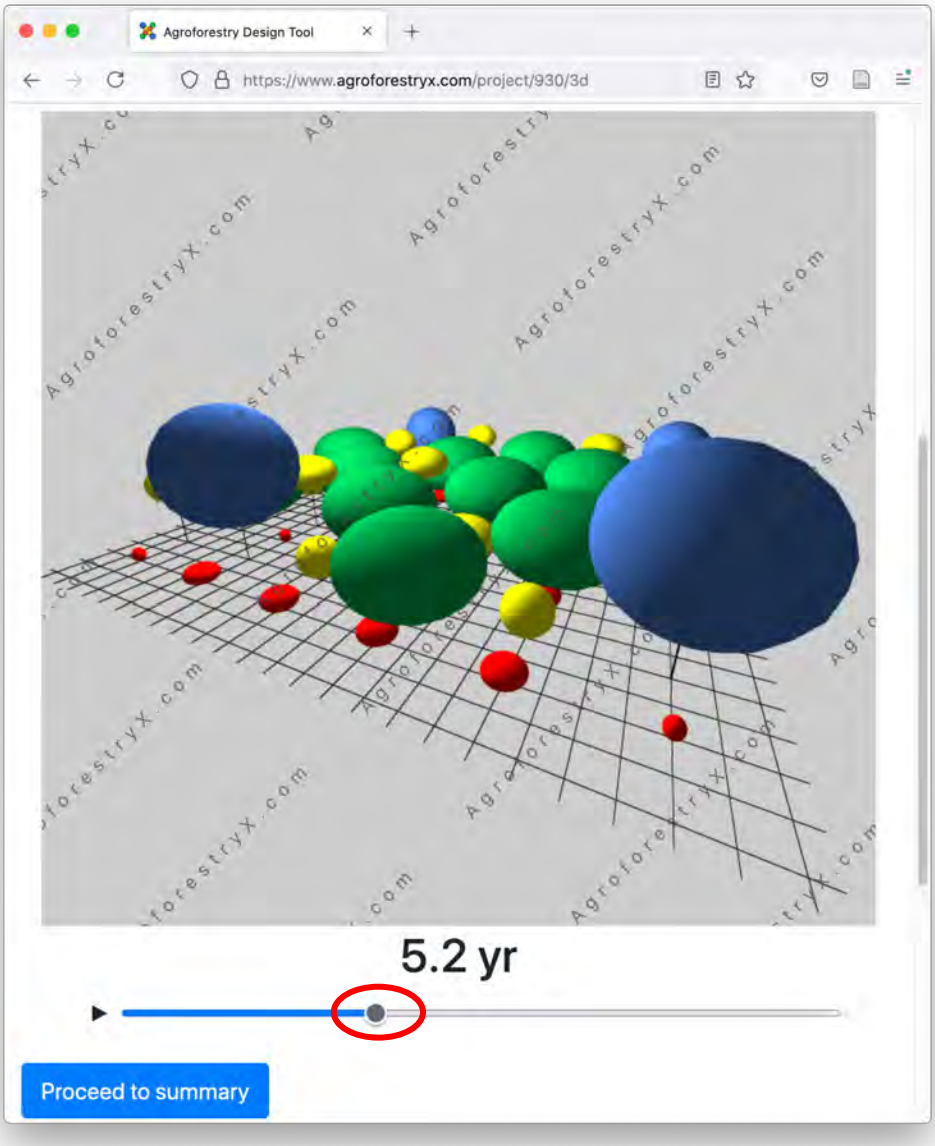


Figure 34: The 3-dimensional animation can be stopped and rotated by clicking and dragging the progress handle with the cursor or moved forward and backward in time.

13 Summary

On the last page a summary of the project design is displayed. Included in the summary are:

- Project details
- Species list organized by term/stratum, with management variables and useful details and tables of short-term crops, groundcovers, and biomass species.
- Visualizations at three stages of development.

The animations are not included in the Summary document.

We highly recommend downloading the project summary, as we cannot guarantee that your data will be available on our servers indefinitely. In other words, downloading the project summary is your best way to preserve the projects you create.

Review the project design summary. If you are satisfied with your project, then print the report or return to the beginning to create a new project. By clicking the logo or banner at the top of the page the user is returned to the home page from any point in the process.

Note that the summary document generated by this tool is not the end of the design process. It should be used to assist in a final design, customized to the site and goals of the project developers. The summary also does not include implementation guidance, which should also be included in the final design.

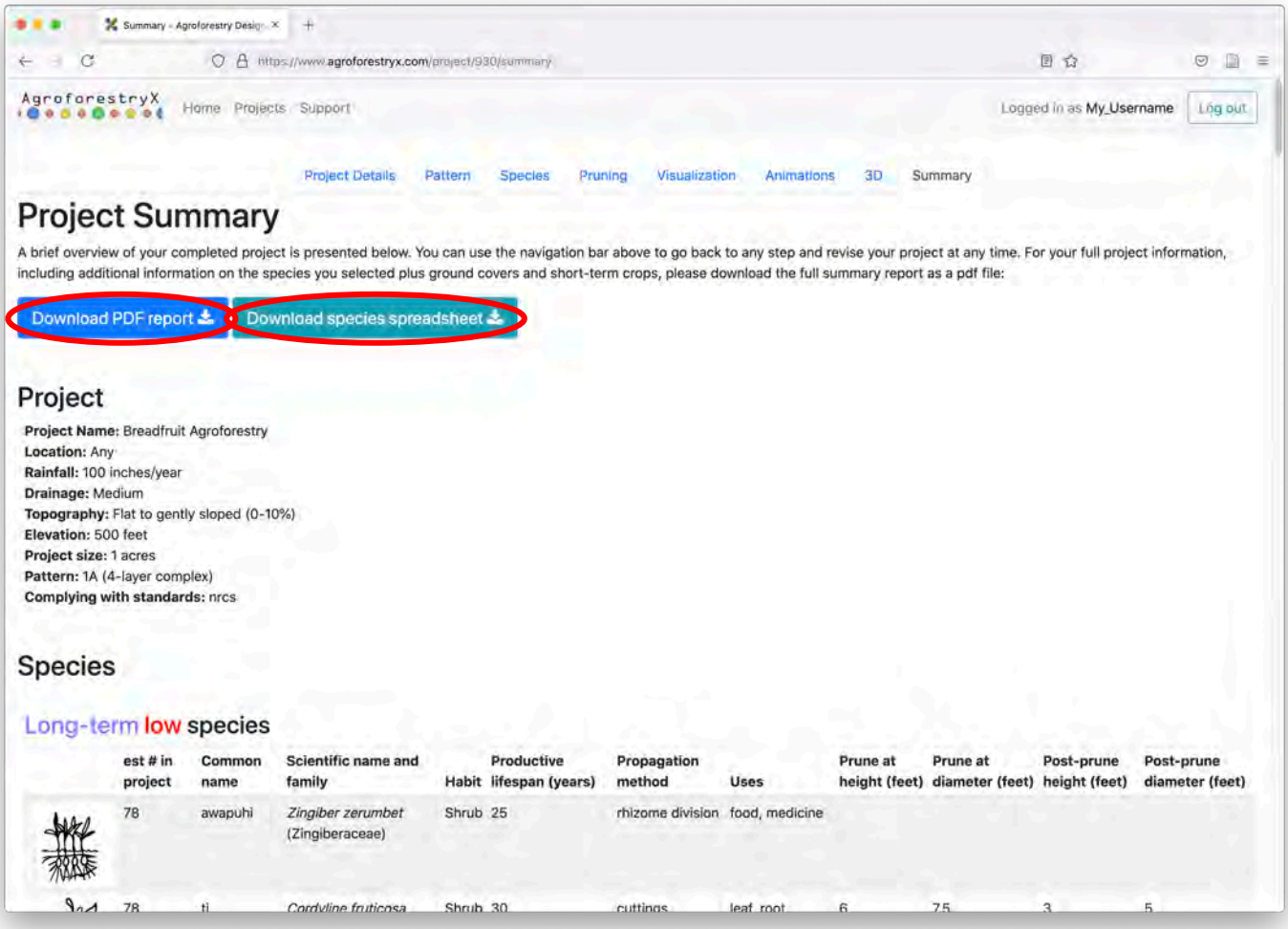


Figure 35: Downloading the project summary is highly recommended, as we cannot guarantee that your project data will be available on our servers indefinitely. Downloading a species list for your project can also be done in Excel format.

13.1 The Summary page won't open. What do I do?

Click the "Proceed to summary" button on the previous pages to save your changes and go to the next step in the process.

13.2 How do I know which species are being used in the visualizations?

Each circled position displayed on a view in the web-based summary is live just as it is in the visualization page (Figure 36).

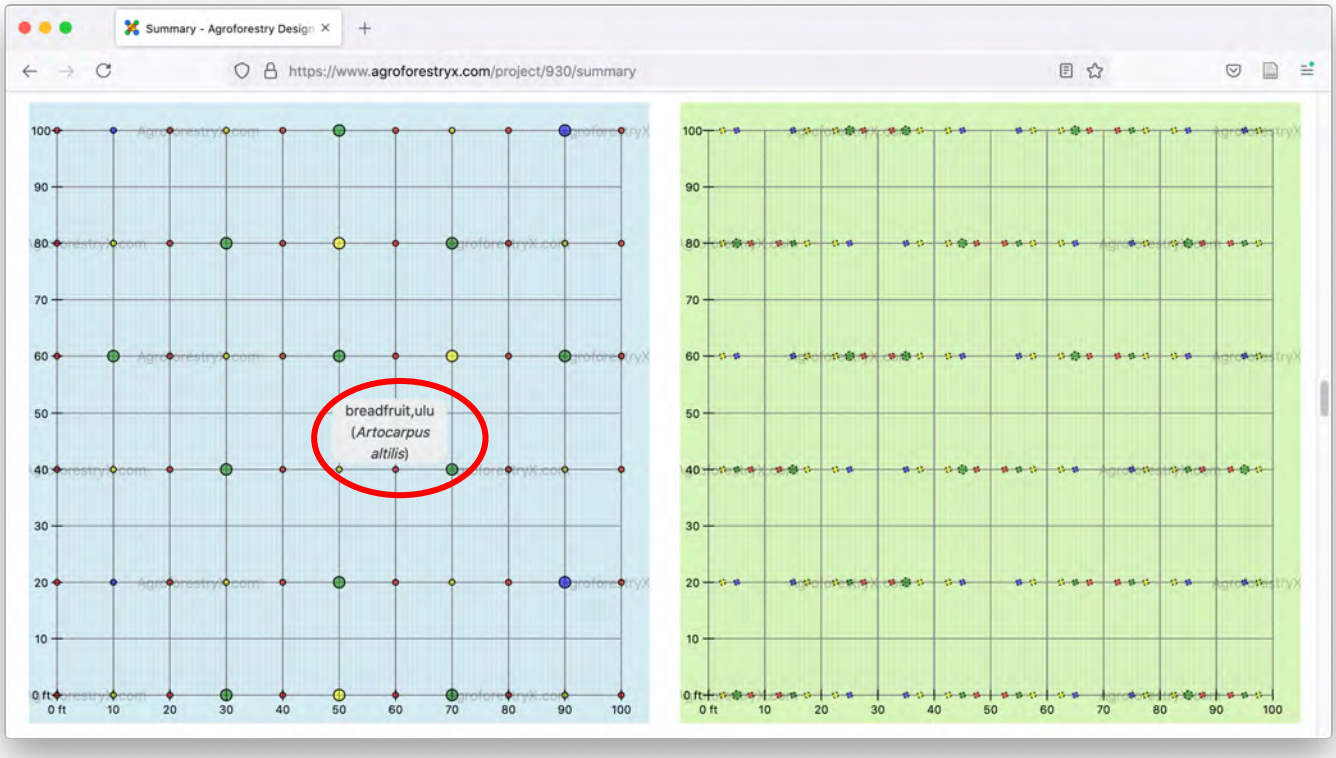


Figure 36: Plant names are shown by placing the cursor over the colored circles.

13.3 Can I change locations of species placed in the visualization?

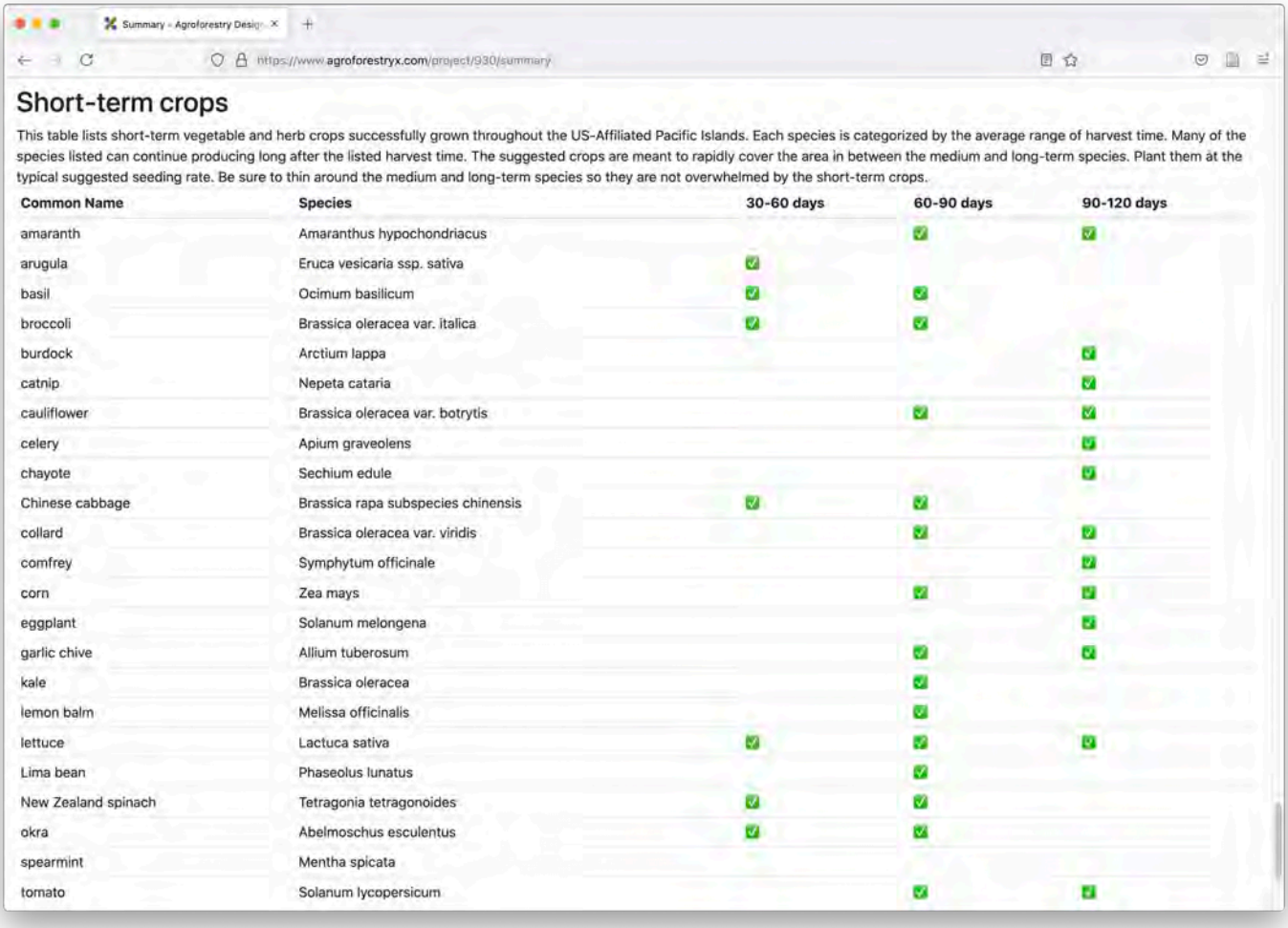
The same protocol as for the visualization page applies here (Section 10.4).

13.4 I would like to have more canopy cover at 10 years. What can I do?

Alter the pruning variables for species selected for the project and/or select more species.

13.5 I found the lists of short-term and ground cover species at the bottom of the Summary page. Is there visualization for them as well?

No, we only provide you with a list of commonly used short-term and ground cover species (Figure 37 and Figure 38). If you require assistance with developing your short-term species plan, we recommend you contact a professional consultant.

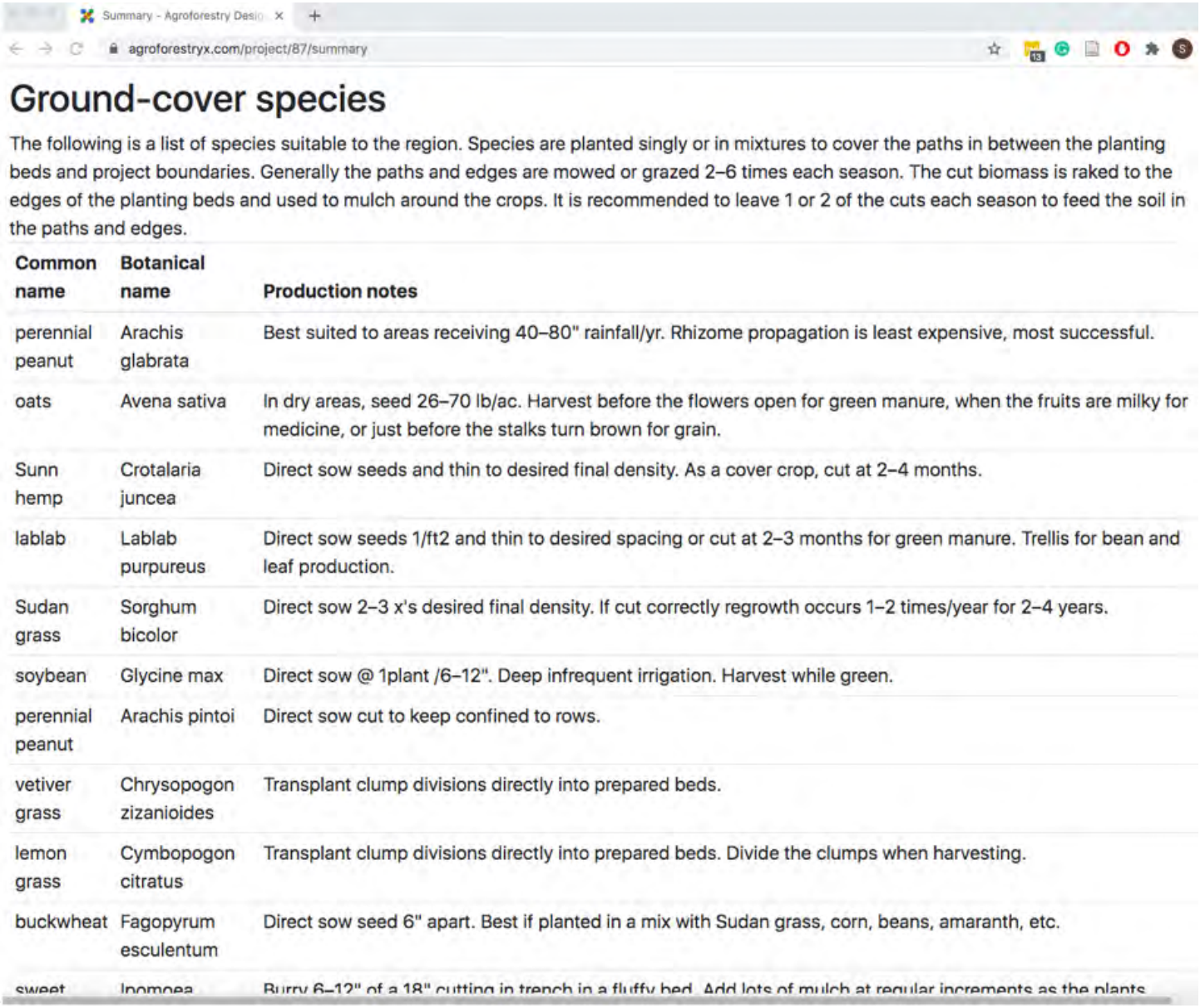


Short-term crops

This table lists short-term vegetable and herb crops successfully grown throughout the US-Affiliated Pacific Islands. Each species is categorized by the average range of harvest time. Many of the species listed can continue producing long after the listed harvest time. The suggested crops are meant to rapidly cover the area in between the medium and long-term species. Plant them at the typical suggested seeding rate. Be sure to thin around the medium and long-term species so they are not overwhelmed by the short-term crops.

Common Name	Species	30-60 days	60-90 days	90-120 days
amaranth	Amaranthus hypochondriacus		✓	✓
arugula	Eruca vesicaria ssp. sativa	✓		
basil	Ocimum basilicum	✓	✓	
broccoli	Brassica oleracea var. italica	✓	✓	
burdock	Arctium lappa			✓
catnip	Nepeta cataria			✓
cauliflower	Brassica oleracea var. botrytis		✓	✓
celery	Apium graveolens			✓
chayote	Sechium edule			✓
Chinese cabbage	Brassica rapa subspecies chinensis	✓	✓	
collard	Brassica oleracea var. viridis		✓	✓
comfrey	Symphytum officinale			✓
corn	Zea mays		✓	✓
eggplant	Solanum melongena			✓
garlic chive	Allium tuberosum		✓	✓
kale	Brassica oleracea		✓	
lemon balm	Melissa officinalis		✓	
lettuce	Lactuca sativa	✓	✓	✓
Lima bean	Phaseolus lunatus		✓	
New Zealand spinach	Tetragonia tetragonoides	✓	✓	
okra	Abelmoschus esculentus	✓	✓	
spearmint	Mentha spicata			
tomato	Solanum lycopersicum		✓	✓

Figure 37: A list of commonly used short-term species is provided for reference and a basic start for selecting short-term species.



Ground-cover species

The following is a list of species suitable to the region. Species are planted singly or in mixtures to cover the paths in between the planting beds and project boundaries. Generally the paths and edges are mowed or grazed 2–6 times each season. The cut biomass is raked to the edges of the planting beds and used to mulch around the crops. It is recommended to leave 1 or 2 of the cuts each season to feed the soil in the paths and edges.

Common name	Botanical name	Production notes
perennial peanut	Arachis glabrata	Best suited to areas receiving 40–80" rainfall/yr. Rhizome propagation is least expensive, most successful.
oats	Avena sativa	In dry areas, seed 26–70 lb/ac. Harvest before the flowers open for green manure, when the fruits are milky for medicine, or just before the stalks turn brown for grain.
Sunn hemp	Crotalaria juncea	Direct sow seeds and thin to desired final density. As a cover crop, cut at 2–4 months.
lablab	Lablab purpureus	Direct sow seeds 1/ft2 and thin to desired spacing or cut at 2–3 months for green manure. Trellis for bean and leaf production.
Sudan grass	Sorghum bicolor	Direct sow 2–3 x's desired final density. If cut correctly regrowth occurs 1–2 times/year for 2–4 years.
soybean	Glycine max	Direct sow @ 1plant /6–12". Deep infrequent irrigation. Harvest while green.
perennial peanut	Arachis pintoi	Direct sow cut to keep confined to rows.
vetiver grass	Chrysopogon zizanioides	Transplant clump divisions directly into prepared beds.
lemon grass	Cymbopogon citratus	Transplant clump divisions directly into prepared beds. Divide the clumps when harvesting.
buckwheat	Fagopyrum esculentum	Direct sow seed 6" apart. Best if planted in a mix with Sudan grass, corn, beans, amaranth, etc.
sweet	Ipomoea	Burry 6–12" of a 18" cutting in trench in a fluffy bed. Add lots of mulch at regular increments as the plants

Figure 38: A list of commonly used ground cover species is provided for reference and a basic start for selecting ground cover species.

14 PDF Report and species list

A pdf version of the report as well as an Excel list of species is available to download from the Summary page (Figure 39). The contents of the pdf are presented at the top of the pdf file

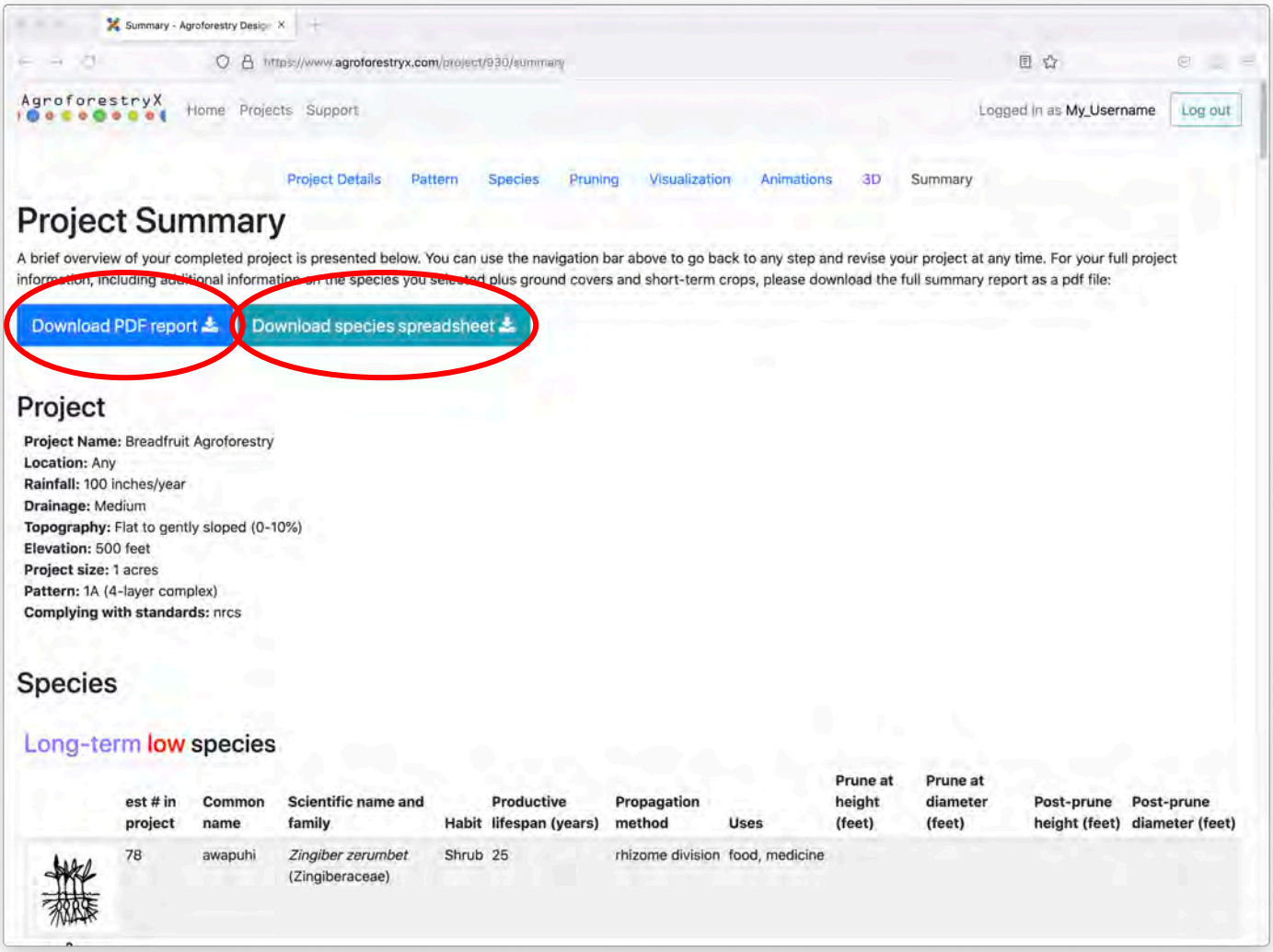


Figure 39: The summary report and species spreadsheet are available for download.

14.1 My PDF report is not loading. What do I do?

Each user may download one pdf report per minute. If an attempt was made to download more reports than the allotted number per minute, then an error script will appear.

14.2 I saved my PDF report but I don't see it. How do I open it?

Saved files should be visible along the bottom of your browser window (Figure 40) or in your browser download history. Find your file there and open it, or open your files and search for a pdf file with the name of your project.

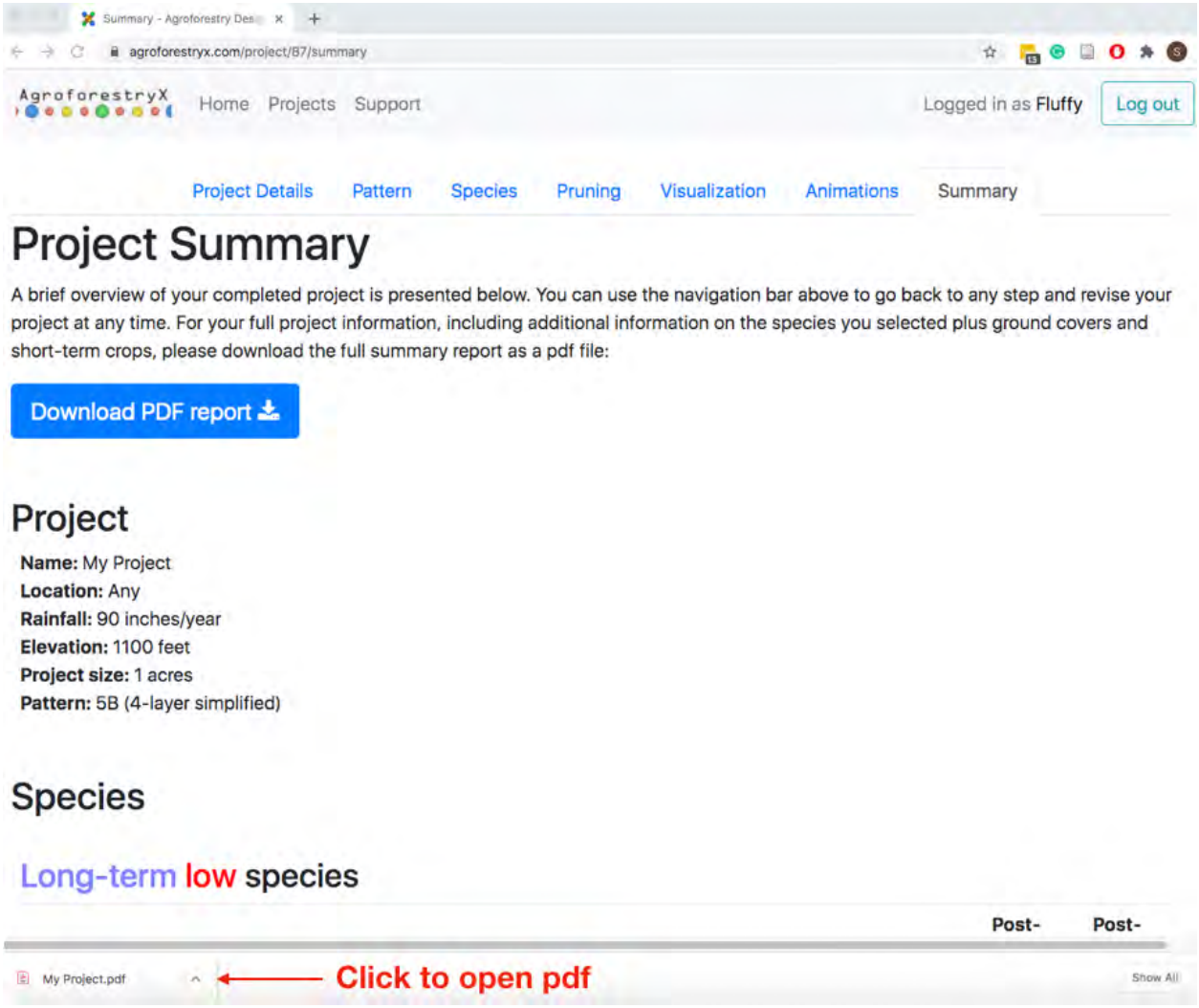


Figure 40: The downloaded file name is shown at the bottom of the screen in some browsers, or in the download history list.

14.3 How does the PDF summary differ from the species spreadsheet?

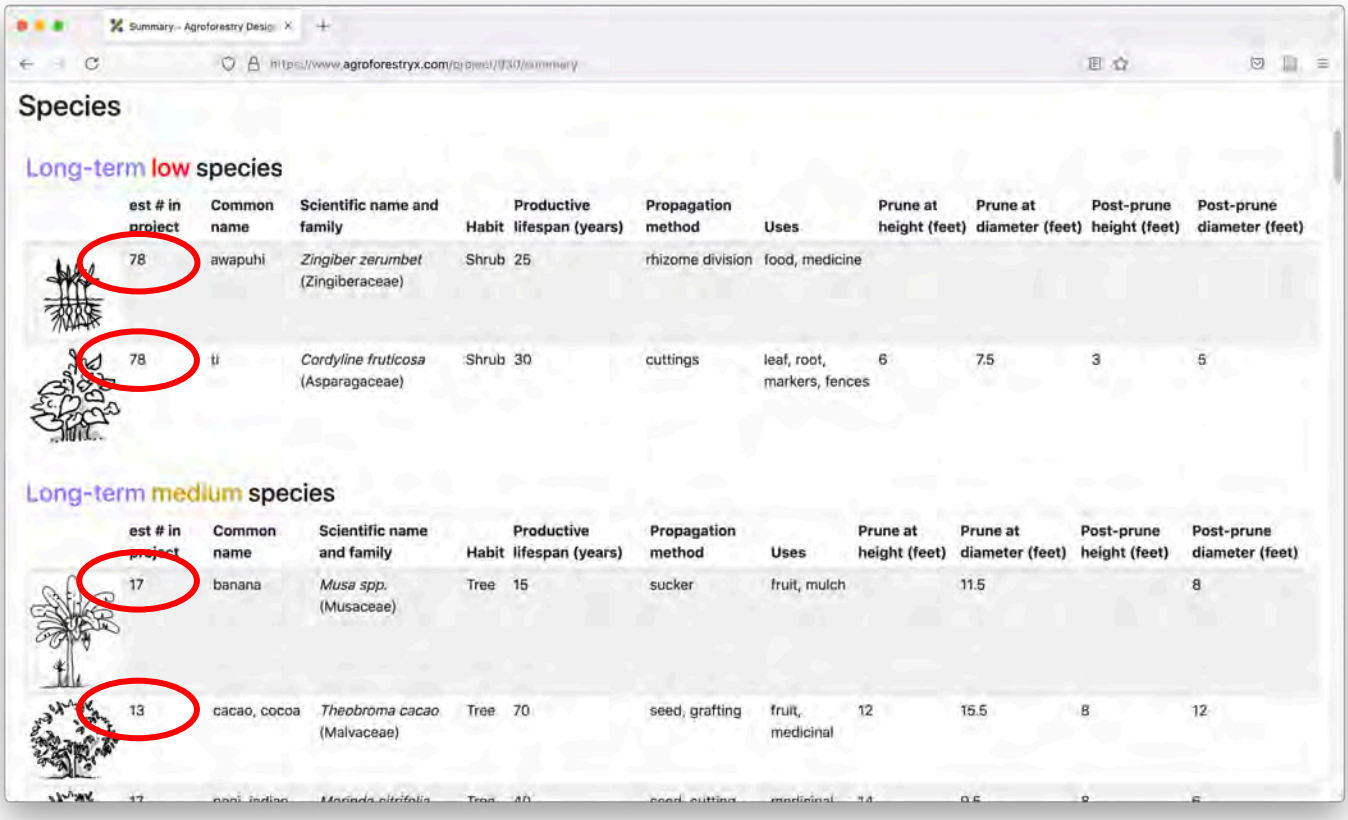
The species spreadsheet is an Excel spreadsheet that lists all the species you have chosen and their approximate quantities required for the project area. This spreadsheet is a starting point for developing your nursery/propagation plan.

14.4 How do I know which species goes in which location on the planting views?

In the pdf visualizations the species names do not pop up on scroll over, as they do in other parts of the tool. From this point, it is up to the user to place species. If you require assistance with this, contact a professional consultant.

14.5 I need a nursery list with numbers of individuals for each species where do I find one?

In the project summary, the first column of the plant list tables displays the estimated number of species in the project (Figure 41). The separately downloaded species spreadsheet gives similar information (Figure 42).



Species

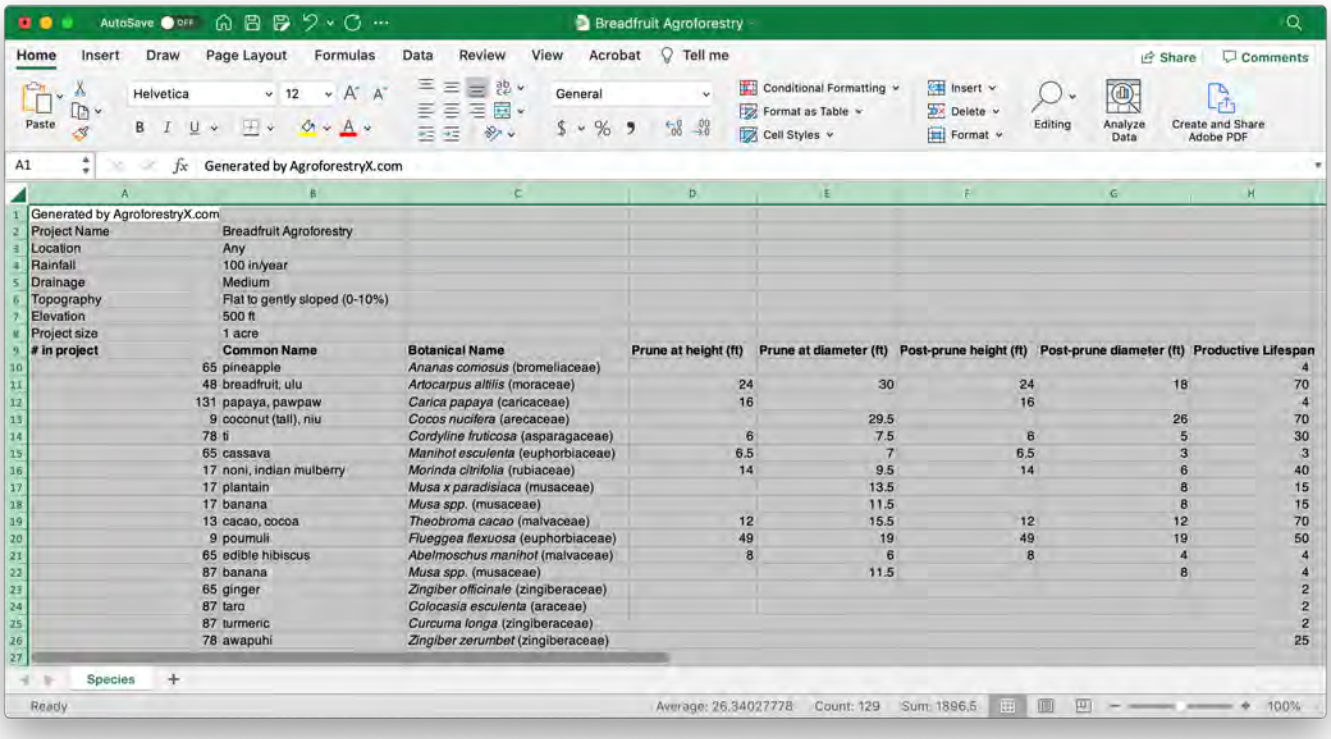
Long-term low species

	est # in project	Common name	Scientific name and family	Habit	Productive lifespan (years)	Propagation method	Uses	Prune at height (feet)	Prune at diameter (feet)	Post-prune height (feet)	Post-prune diameter (feet)
	78	awapuhi	*Zingiber zerumbet* (Zingiberaceae)	Shrub	25	rhizome division	food, medicine				
	78	ti	*Cordyline fruticosa* (Asparagaceae)	Shrub	30	cuttings	leaf, root, markers, fences	6	7.5	3	5

Long-term medium species

	est # in project	Common name	Scientific name and family	Habit	Productive lifespan (years)	Propagation method	Uses	Prune at height (feet)	Prune at diameter (feet)	Post-prune height (feet)	Post-prune diameter (feet)
	17	banana	*Musa spp.* (Musaceae)	Tree	15	sucker	fruit, mulch		11.5		8
	13	cacao, cocoa	*Theobroma cacao* (Malvaceae)	Tree	70	seed, grafting	fruit, medicinal	12	15.5	8	12

Figure 41: Species counts are given in the project summary along with brief species information on propagation and uses.



Generated by AgroforestryX.com

Project Name	Breadfruit Agroforestry
Location	Any
Rainfall	100 in/year
Drainage	Medium
Topography	Flat to gently sloped (0-10%)
Elevation	500 ft
Project size	1 acre

# in project	Common Name	Botanical Name	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)	Productive Lifespan
65	pineapple	*Ananas comosus* (bromeliaceae)					4
48	breadfruit, ulu	*Artocarpus altilis* (moraceae)	24	30	24	18	70
131	papaya, pawpaw	*Carica papaya* (caricaceae)	16		16		4
9	coconut (tall), niu	*Cocos nucifera* (arecaceae)		29.5		26	70
78	ti	*Cordyline fruticosa* (asparagaceae)	6	7.5	6	5	30
65	cassava	*Manihot esculenta* (euphorbiaceae)	6.5	7	6.5	3	3
17	noni, indian mulberry	*Morinda citrifolia* (rubiaceae)	14	9.5	14	6	40
17	plantain	*Musa x paradisiaca* (musaceae)		13.5		8	15
17	banana	*Musa spp.* (musaceae)		11.5		8	15
13	cacao, cocoa	*Theobroma cacao* (malvaceae)	12	15.5	12	12	70
9	poumuli	*Flueggea flexuosa* (euphorbiaceae)	49	19	49	19	50
65	edible hibiscus	*Abelmoschus manihot* (malvaceae)	8	6	8	4	4
87	banana	*Musa spp.* (musaceae)		11.5		8	4
65	ginger	*Zingiber officinale* (zingiberaceae)					2
87	taro	*Colocasia esculenta* (araceae)					2
87	turmeric	*Curcuma longa* (zingiberaceae)					2
78	awapuhi	*Zingiber zerumbet* (zingiberaceae)					25

Figure 42: The species spreadsheet can be used to start a nursery/propagation plan for the project.

14.6 How do I use this report once I print it?

The summary has basic information about the species selected for that project. The summary can be used to plan for nursery stock and other germplasm necessary for the project. It also contains production notes and pruning variables for canopy management through time.

14.7 How can I use this report to install my project?

The installation process is highly individual depending upon site conditions, equipment and labor available, and experience. Therefore, installation planning is not included in this tool. If you require assistance with this, we recommend you contact a professional consultant.

15 Adapting the Tool's design to your site

Use of this planning tool is a powerful start to your planning process, but more planning needs to be done to customize the ADT's patterns to your site. For sites larger than the pattern (100 ft x 100 ft), the project area can be covered by stitching together the pattern to cover the entire area (Figure 43). For smaller project areas, a portion of the pattern is chosen to fit the dimensions of the site (Figure 44).

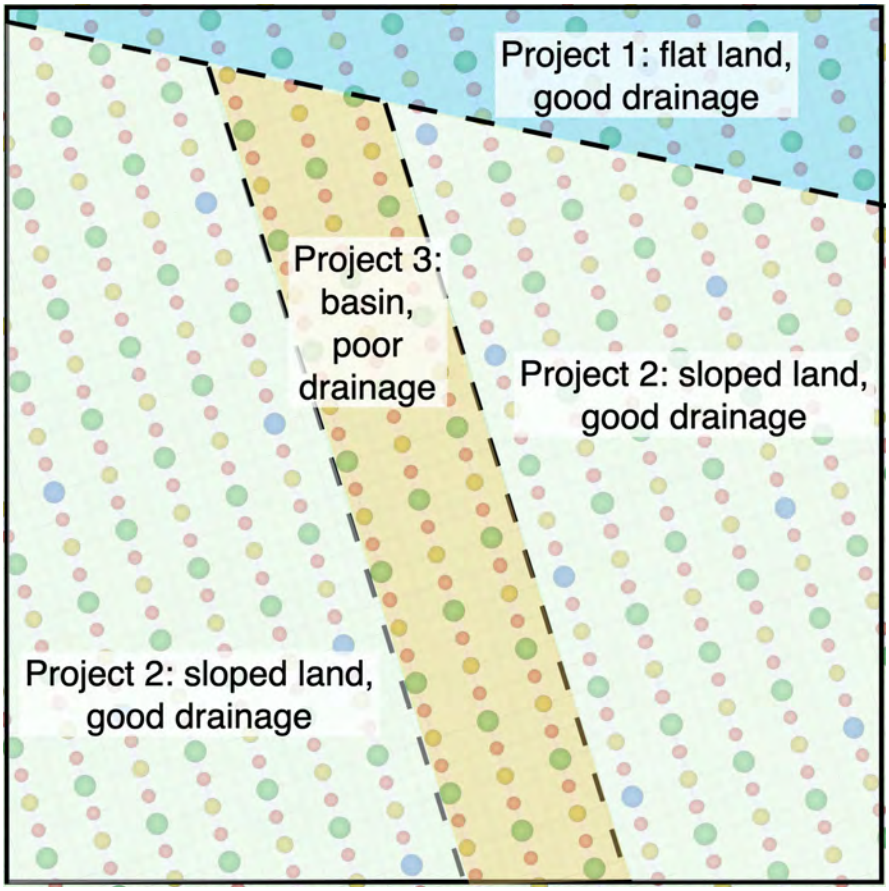


Figure 43: The pattern generated for each project area needs to be placed on your site map. This will usually require stitching together the 100 ft x 100 ft template in order to cover the entire area.

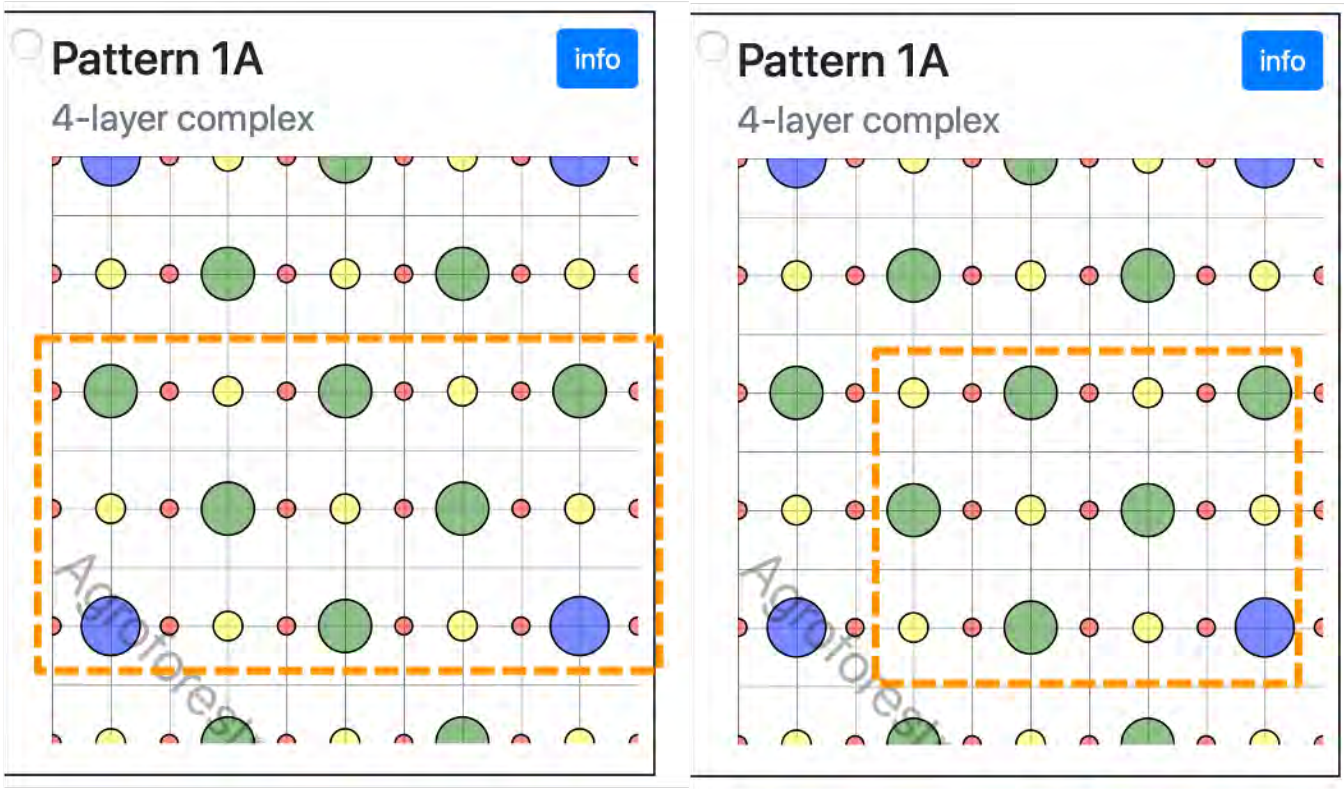


Figure 44: For project areas smaller than the 100 ft x 100 ft pattern, a portion of the pattern can be chosen. On the left, three rows are chosen for a 3-row windbreak and on the right, a

16 References

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17 About the ADT creators

Craig Elevitch, PhD has worked in agroforestry since 1991. He has consulted for numerous landowners and managers, including authoring dozens of agroforestry, Forest Stewardship, and native forest dedication plans throughout Oceania and the tropics. Craig's internationally recognized publications and workshops have guided thousands in becoming more proficient in regenerative agroforestry and reforestation. He has 14 books to his credit including *Agroforestry Guides for Pacific Islands* (2000), *Traditional Trees of Pacific Islands: Their culture, environment, and use* (2006), *Specialty Crops for Pacific Islands* (2011), *Agroforestry Landscapes for Pacific Islands: Creating abundant and resilient food systems* (2015), and *Agroforestry Design for Regenerative Production* (2021, in press). His agroforestry publications have been downloaded millions of times. In addition to working directly with dozens of growers, consultants, and educators, he has facilitated over 180 agroforestry workshops in the Pacific, with over 8,000 producers and resource professionals participating since 1993. He was honored with the Shining Stars of Oceania award in 2019 and the Global Aloha 'Aina 'Ohana award in 2016. Craig holds a PhD in Electrical Engineering (Systems) from Cornell University for research focusing on agroforestry growth modeling.

Sophia Bowart, BFA, MBA is committed to regenerating degraded lands using successional agroforestry and teaching such techniques to the world. After being introduced to this work by Ernst Gotsch, Dr. Craig Elevitch and her husband, Neil Logan, Sophia has been implementing successional agroforestry techniques on Mohala Lehua Farm in North Kohala, Hawaii since 2008. In addition to converting former pastureland into a diverse, multistory agroforest, she has been developing a range of value-added-products from the farm in order to offset the cost of planting and maintenance. Over the last 10 years, Sophia has developed techniques for elucidating financial analysis of complex agro-ecosystems throughout the project lifecycle. She recently published an in-depth financial analysis guide for multistory agroforestry (Bowart and Logan 2020) and is currently Research Analyst and Project Administrator for the NRCS-PIA project "Pacific Island CIG agroforestry design tools and professional development workshops" (2018–2020).

Neil Logan is a specialist in the research and development of natural products and the agro-ecological and socio-cultural contexts that support them. With agroforestry experience on three continents, in both arid and wet conditions, temperate to tropical, Neil is also trained in western herbalism, natural products development (with over 25 years' experience), and in relational database and web-based software systems. From 2000-2002, Neil developed an on-line relational database for the Greater Southwest bioregion, creating a novel system for organizing and managing natural and cultural resources. From 2001–present, Neil is a teacher of agroforestry, horticulture, mycoculture and information technology via workshops, lectures, publications and presentations. In 2006, Neil founded the ecological consulting firm, Integrated Living Systems Design LLC, where he focused on the development of living fuel breaks and fire mitigation for clients in arid lands of Hawaii. He now co-directs FARM Center with his wife, Sophia Bowart. Most recently, Neil co-authored the forthcoming book *Agroforestry Design for Regenerative Production* (2021, in press) and *Kiawe: A Prosopis in Hawaii* (2021, in press). He is also Lead Developer for the 2018–2020 NRCS-PIA project "Pacific Island CIG agroforestry design tools and professional development workshops."**Error! Hyperlink reference not valid.**

Our team has over 70 years combined experience in agroforestry education, design, and field implementation and management. We specialize in increasing the capacity of our clients to best successful in regenerative agroforestry. For more information about our services, visit Agroforestry.com.

18 Example Summary Report

The following report was generated from the example project used in this manual.

AgroforestryX

Summary report

This design guide was generated by the Agroforestry Design Tool™ (ADT) to help plan an agroforest tailored to your site and species selections. The Agroforestry Design Tool™ helps the user in selecting species, creating a geometric planting layout, and in visualizing how the planting will look over time. The ADT should be seen as assisting the user in the design process, but it is not a replacement for the expertise of those familiar with local environmental and economic conditions. **Expert consultation should always be sought before implementation.**

This design guide *provides*

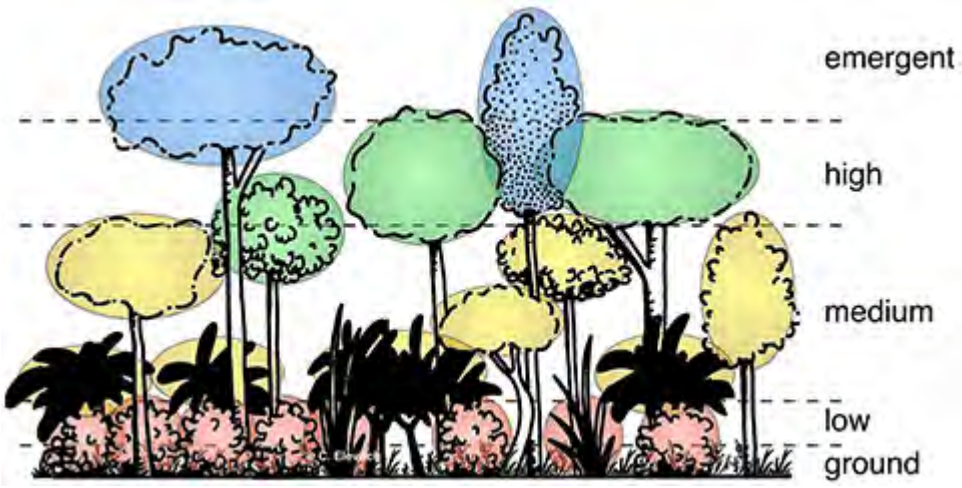
- Project Details (from your input to the Tool)
- Initial Planting Patterns
  - Long-term
  - Plant list
  - Medium-term
  - Plant list
- 3-Year Visualizations
  - Long-term overview
  - Medium-term overview
  - Medium-term side view
- 10-Year Visualizations
  - Long-term overview
  - Long-term side view
- Species Details
  - Long-term plants
  - Medium-term plants
  - Ground covers
  - Short-term crops

This design guide *does not provide*

- Project-specific expertise or instructions needed for a successful installation.
- Specific installation and management guidelines.
- Site-specific maps for placement of the rows shown in the pattern.
- Any assurance that your implementation will succeed.

Any tree-planting project can involve a significant investment of time, money, and labor. We highly recommend you consult with agroforestry experts in developing a comprehensive plan.

The Agroforestry Design Tool is based upon positioning plant species that occupy different forest layers in orientation to each other in time and space (short-, medium-, and long-term crops). The arrangement of crop species in both time and space leads to an agroforest designed to mimic a natural forest ecosystem in both structure and function. The layer each species occupies is determined by light needs and niche occupied in their respective ecosystems of origin. The layers are color-coded to assist the user in interpreting their planting configuration. The color system we use for the different layers is illustrated in the figure below, with the approximate relative heights of the species (if allowed to grow naturally without pruning) given in the table.



Layers of the multistory agroforest design.

Stratum (layer height class)	Icon color	Light requirements	Long-term species (4+ years)	Medium-term species (0–4 years)	Short-term species (0–2 years)
Emergent		Full sun	40+ ft	12+ ft	not illustrated
High		≈80% sunlight	≈18-40 ft	≈6–12 ft	not illustrated
Medium		≈60% sunlight	≈10-20 ft	≈4–8 ft	not illustrated
Low		≈40% sunlight	≈2-12 ft	≈2–6 ft	not illustrated
Ground	not illustrated	20-80% depending on location relative to trees	—	—	—

Agroforestry Design Tool authors and sponsors

This work is a collaboration of Permanent Agriculture Resources and Forest Agriculture Research Management Center (FARM Center). This material is based upon work supported in part by the Natural Resources Conservation Service, U.S. Department of Agriculture, under number NR1892510002G002. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.

Disclaimer

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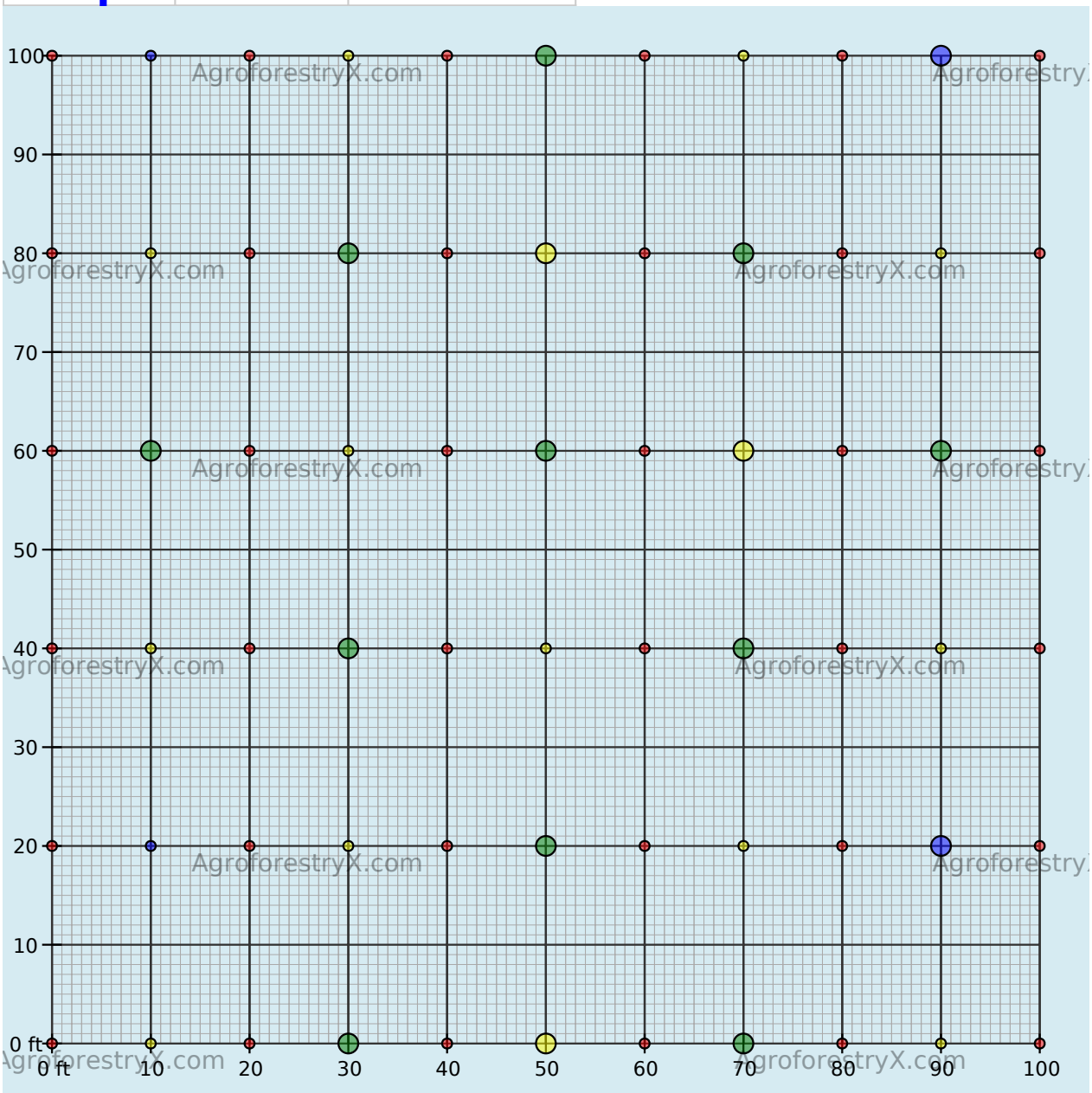
- Elevitch, C.R. (ed). 2006. *Traditional Trees of Pacific Islands: Their Culture, Environment, and Use*. PAR, Hawaii. 816 pp.

Project details

Name	Breadfruit Agroforestry
Location	Any
Rainfall	100 inches/year
Soil drainage	Medium
Topography	Flat to gently sloped (0-10%)
Elevation	500 feet
Project size	1 acres
Standards	nrcs
Pattern	Pattern 1A

Initial planting patterns: Long-term initial planting

	color	in row spacing (ft)	between row spacing (ft)
low	red	20	20
medium	yellow	40	20
high	green	40 & 80	20
emergent	blue	80	80



Plant list (see further details below)

Long-term low species

est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
78	awapuhi	*Zingiber zerumbet* (Zingiberaceae)	Shrub	25	none	none	none	none
78	ti	*Cordyline fruticosa* (Asparagaceae)	Shrub	30	6	7.5	3	5

Long-term medium species

est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
17	banana	*Musa spp.* (Musaceae)	Tree	15	none	11.5	none	8
13	cacao, cocoa	*Theobroma cacao* (Malvaceae)	Tree	70	12	15.5	8	12
17	noni, indian mulberry	*Morinda citrifolia* (Rubiaceae)	Tree	40	14	9.5	8	6
17	plantain	*Musa x paradisiaca* (Musaceae)	Tree	15	none	13.5	none	8

Long-term high species

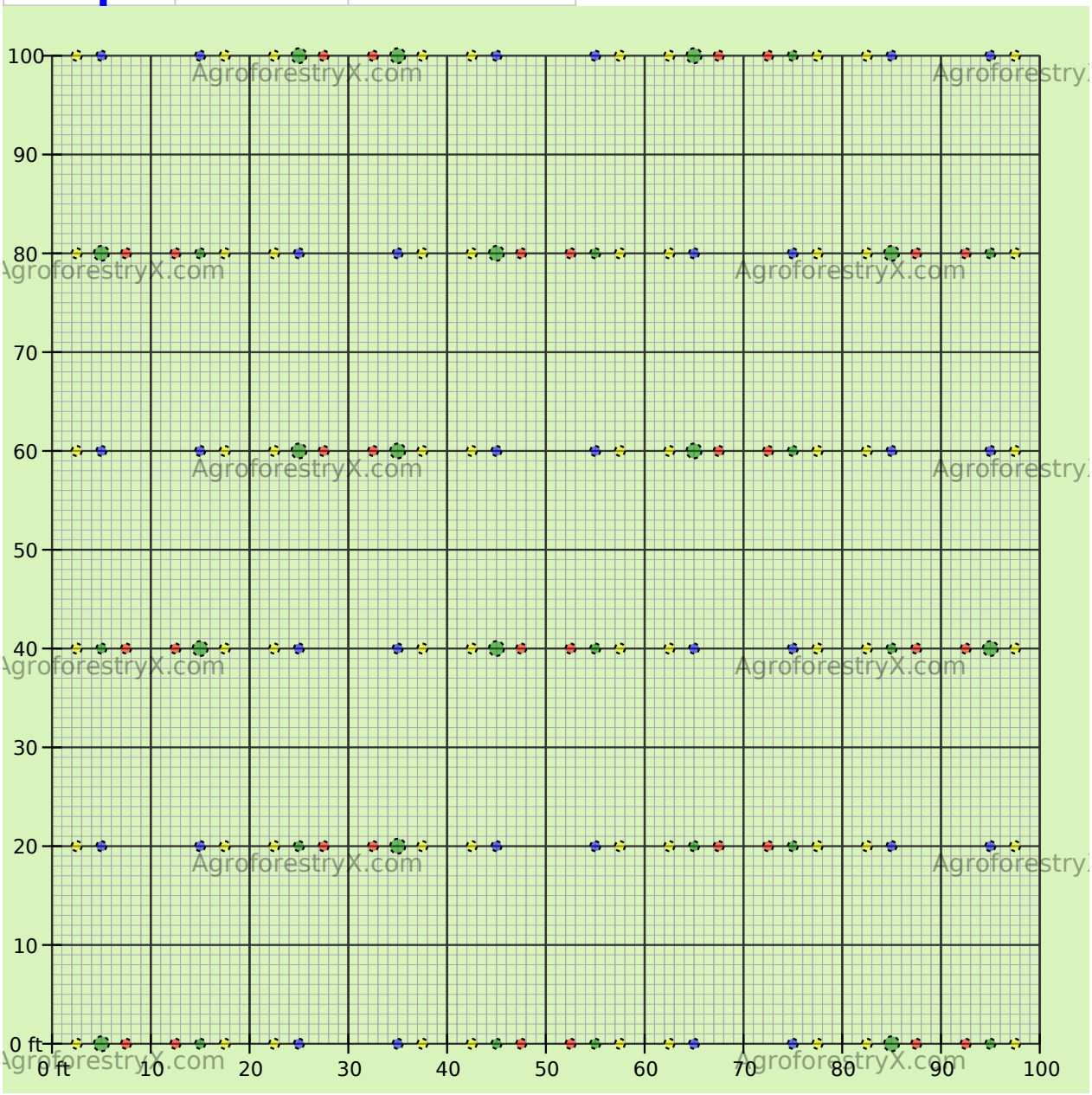
est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
48	breadfruit, ulu	*Artocarpus altilis* (Moraceae)	Tree	70	24	30	14	18

Long-term emergent species

est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
9	coconut (tall), niu	*Cocos nucifera* (Arecaceae)	Palm	70	none	29.5	none	26
9	poumuli	*Flueggea flexuosa* (Euphorbiaceae)	Tree	50	49	19	49	19

Initial planting patterns: Medium-term initial planting

	color	in row spacing (ft)	between row spacing (ft)
low	red	20	20
medium	yellow	40	20
high	green	40 & 80	20
emergent	blue	80	80



Plant list (see further details below)

Medium-term low species

est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
65	ginger	*Zingiber officinale* (Zingiberaceae)	Shrub	2	none	none	none	none
65	pineapple	*Ananas comosus* (Bromeliaceae)	Herb	4	none	none	none	none

Medium-term medium species

est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
87	banana	*Musa spp.* (Musaceae)	Tree	4	none	11.5	none	8
87	taro	*Colocasia esculenta* (Araceae)	Shrub	2	none	none	none	none
87	turmeric	*Curcuma longa* (Zingiberaceae)	Shrub	2	none	none	none	none

Medium-term high species

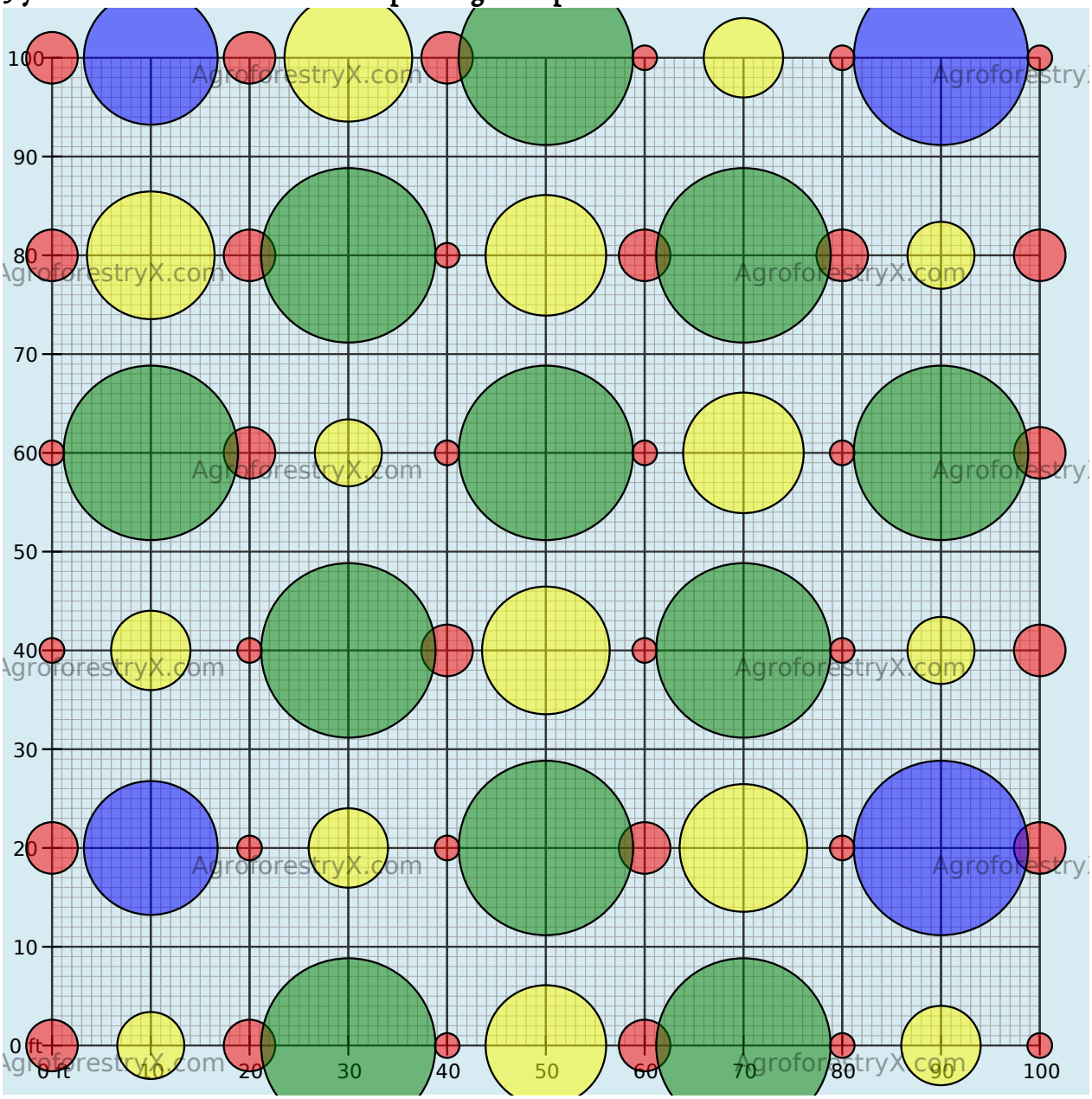
est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
65	cassava	*Manihot esculenta* (Euphorbiaceae)	Tree	3	6.5	7	3	3
65	edible hibiscus	*Abelmoschus manihot* (Malvaceae)	Tree	4	8	6	4	4

Medium-term emergent species

est # in project	Common name	Botanical name	Habit	Lifespan	Prune at height (ft)	Prune at diameter (ft)	Post-prune height (ft)	Post-prune diameter (ft)
131	papaya, pawpaw	*Carica papaya* (Caricaceae)	Tree	4	16	none	8	none

3-year visualizations

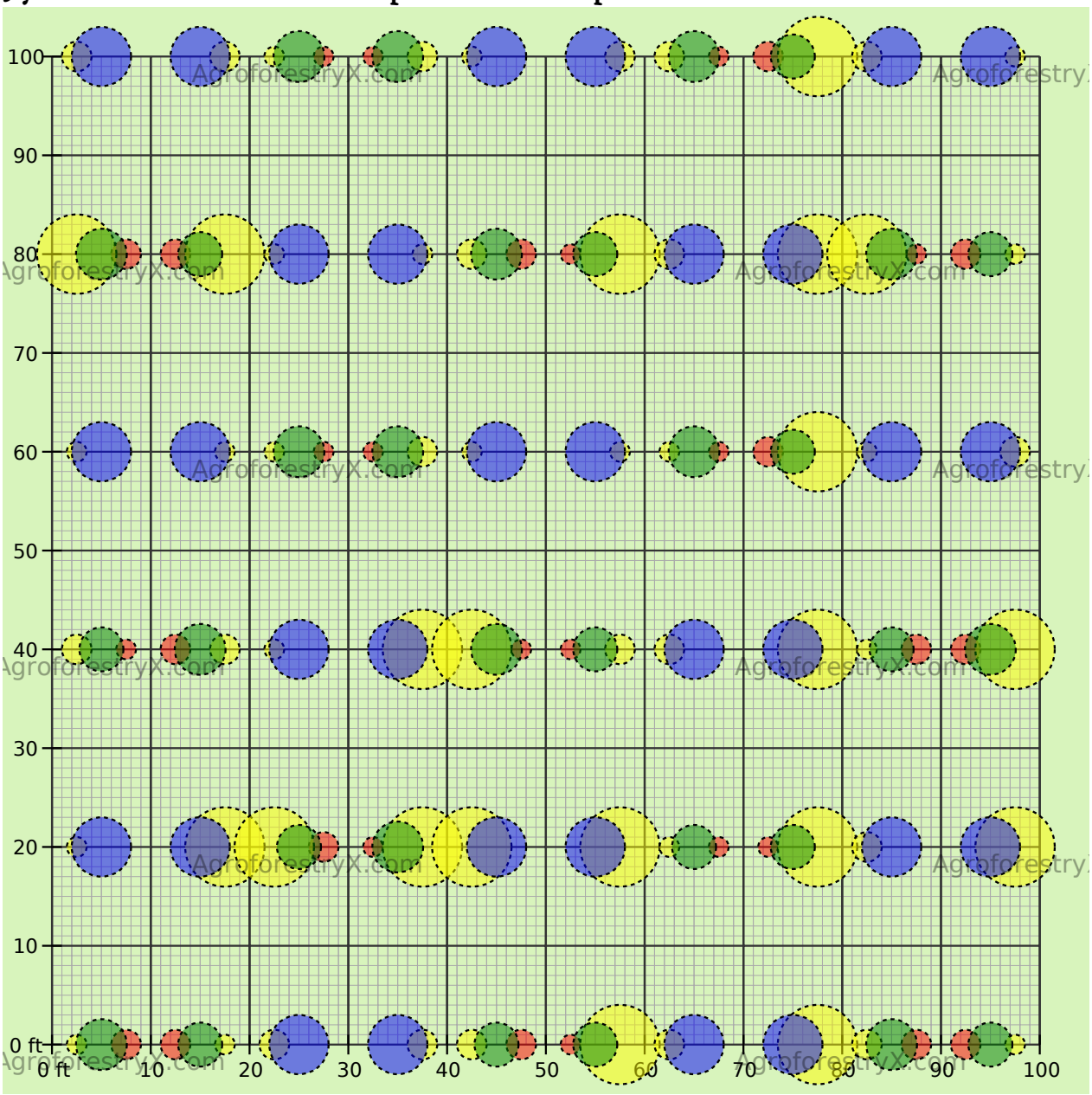
3-year overview visualization of canopies long-term plants



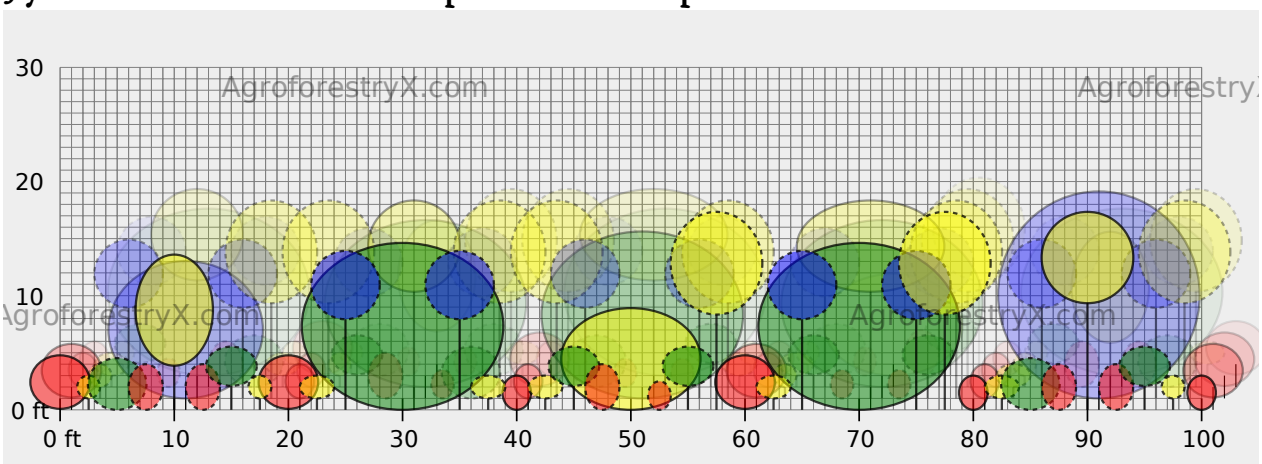
Canopy cover estimated at 3 years

Stratum	% Cover Long-term	% Cover Medium-term
Low	3	1
Medium	10	11
High	23	5
Emergent	6	7
Total	43	24

3-year overview visualization of canopies medium-term plants

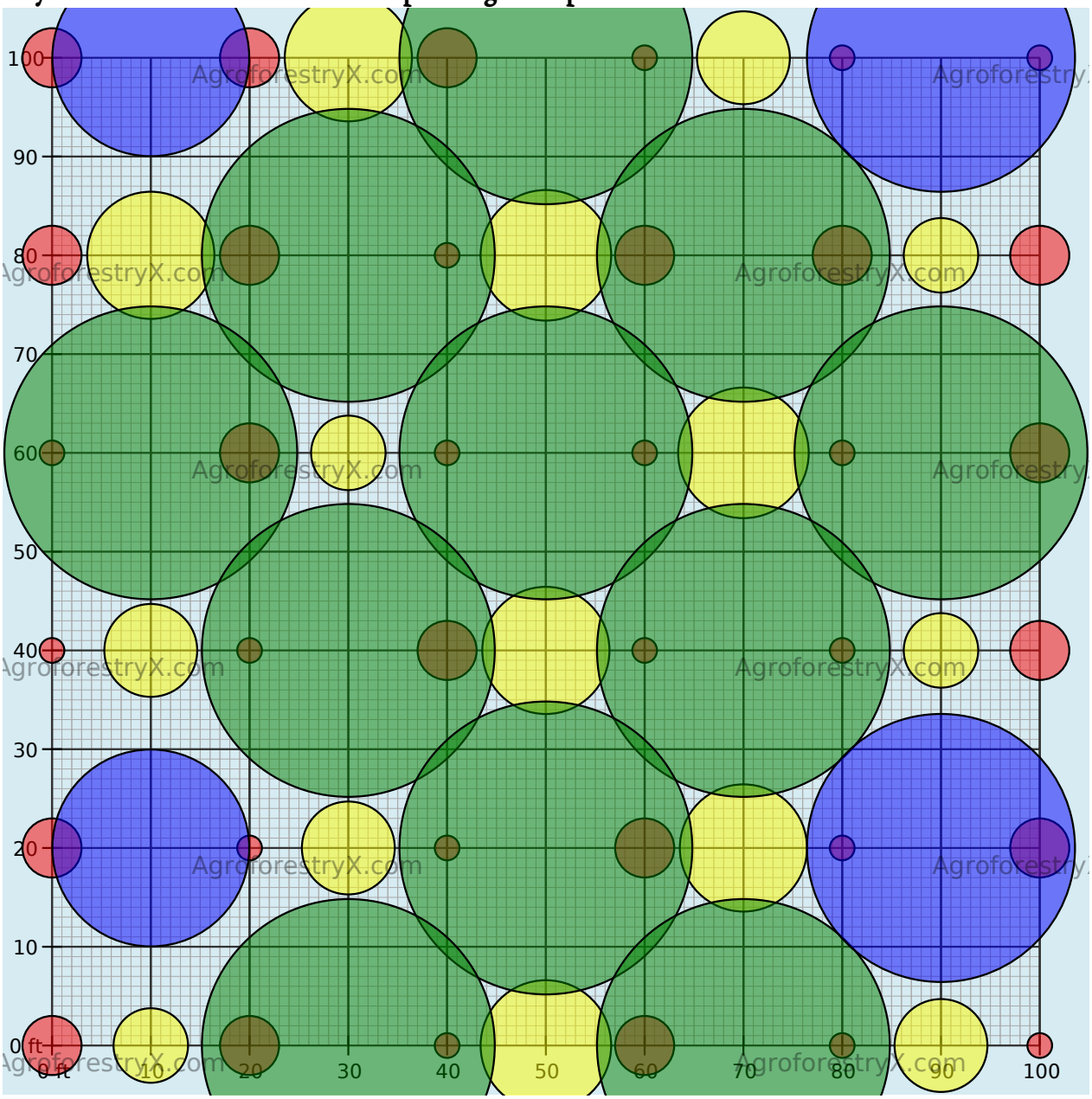


3-year sideview visualization of canopies medium-term plants



10-year visualizations

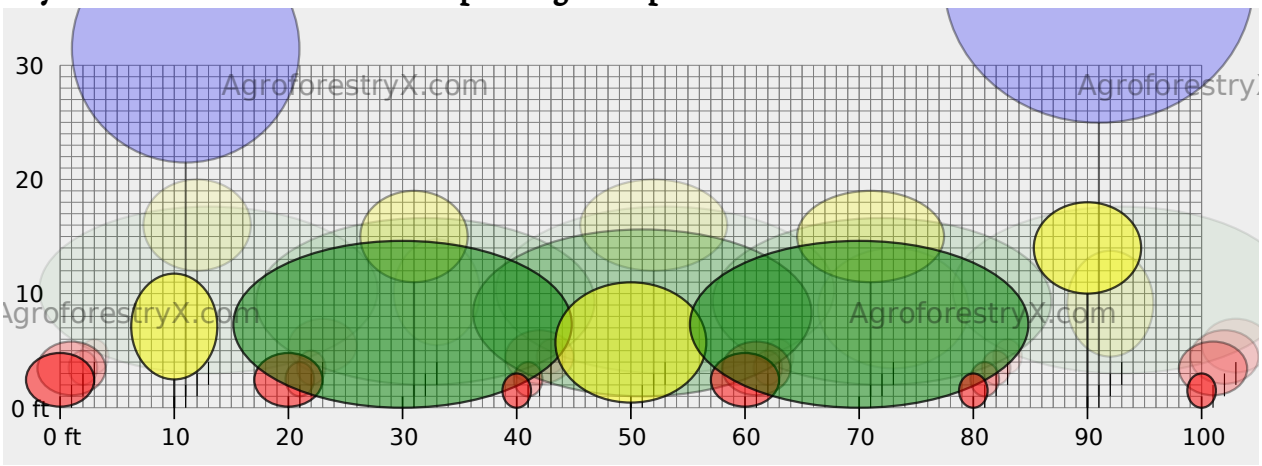
10-year overview visualization of canopies long-term plants



Canopy cover estimated at 10 years

Stratum	% Cover Long-term
Low	4
Medium	12
High	64
Emergent	13
Total	92

10-year sideview visualization of canopies long-term plants



Species Details

Long-term low species

Common name: awapuhi
Habit: Shrub

Propagation methods: rhizome division
Uses: food, medicine
Production Notes: Prefers fluffy soil with lots of organic matter. Yield ~.5 - 1 kg/plant.

Common name: ti
Habit: Shrub

Propagation methods: cuttings
Uses: leaf, root, markers, fences
Production Notes: Root production requires 9-24 months before harvest. (Simpson 2012)

Long-term medium species

Common name: banana
Habit: Tree

Propagation methods: sucker
Uses: fruit, mulch
Production Notes: Begins in 12–18 months, can continue for many years if managed.

Common name: cacao, cocoa
Habit: Tree

Propagation methods: seed, grafting
Uses: fruit, medicinal
Production Notes: Begins in Year 3 and continues for decades.

Common name: noni, indian mulberry
Habit: Tree

Propagation methods: seed, cutting
Uses: medicinal
Production Notes: Begins in 2–3 years, can continue for decades. (Nelson 2006)

Common name: plantain
Habit: Tree

Propagation methods: sucker
Uses: fruit
Production Notes: Transplanted suckers require 9-24 months before producing fruit. (Elevitch 2006)

Long-term high species

Common name: breadfruit, ulu
Habit: Tree

Propagation methods: seed, sucker, root cutting
Uses: fruit, nut, staple food
Production Notes: Begins in 3–4 years, with commercial quantities in Year 5 with productive life of 50+ years.

Long-term emergent species

Common name: coconut (tall), niu
Habit: Palm

Propagation methods: seed
Uses: nut, seed oil, beverage, fiber, bee forage
Production Notes: Begins in Year 6 with productive life of 40–50 years.

Common name: poumuli
Habit: Tree

Propagation methods: seed
Uses: crafts, lumber, fence, medicine, fuel wood
Production Notes: Plant at tighter spacing for fuel wood, poles, posts, and wider spacing when intercropping. Trees are often harvested at about 8-10 years after planting.

Medium-term low species

Common name: ginger
Habit: Shrub

Propagation methods: rhizome division
Uses: food, medicine
Production Notes: Prefers fluffy soil with lots of organic matter. Yield ~.5 - 1 kg/plant.

Common name: pineapple
Habit: Herb

Propagation methods: sucker
Uses: fruit
Production Notes: Fruiting begins in 12–18 months with a productive life through Year 4.

Medium-term medium species

Common name: banana
Habit: Tree

Propagation methods: sucker
Uses: fruit, mulch
Production Notes: Begins in 12–18 months, can continue for many years if managed.

Common name: taro
Habit: Shrub

Propagation methods: corm division
Uses: food, medicine
Production Notes: Prefers fluffy soil with lots of organic matter. Yield ~.5 - 2 kg/plant.

Common name: turmeric
Habit: Shrub

Propagation methods: rhizome division
Uses: food, medicine
Production Notes: Prefers fluffy soil with lots of organic matter. Yield ~.5 - 1 kg/plant.

Medium-term high species

Common name: cassava
Habit: Tree

Propagation methods: cutting
Uses: root, leaf
Production Notes: Root harvest requires 9-24 months depending on variety. (Duke 1983)

Common name: edible hibiscus
Habit: Tree

Propagation methods: seed, cutting
Uses: food, medicine, dye, textile, craft
Production Notes: Plant healed cuttings direct in the field. Allow the establishment of a few leaves before watering the cuttings to avoid rot. Harvest the leaves as soon as mature to avoid pests.

Medium-term emergent species

Common name: papaya, pawpaw
Habit: Tree

Propagation methods: seed
Uses: fruit, medicinal
Production Notes: Fruiting begins in 12–18 months with 2–3 years of production before removal.

Ground-cover species

The following is a list of species suitable to the region. Species are planted singly or in mixtures to cover the paths in between the planting beds and project boundaries. Generally the paths and edges are mowed or grazed 2–6 times each season. The cut biomass is raked to the edges of the planting beds and used to mulch around the crops. It is recommended to leave 1 or 2 of the cuts each season to feed the soil in the paths and edges.

Common name	Botanical name	Production notes
perennial peanut	Arachis glabrata	Best suited to areas receiving 40–80" rainfall/yr. Rhizome propagation is least expensive, most successful.
oats	Avena sativa	In dry areas, seed 26–70 lb/ac. Harvest before the flowers open for green manure, when the fruits are milky for medicine, or just before the stalks turn brown for grain.
Sunn hemp	Crotalaria juncea	Direct sow seeds and thin to desired final density. As a cover crop, cut at 2–4 months.
lablab	Lablab purpureus	Direct sow seeds 1/ft2 and thin to desired spacing or cut at 2–3 months for green manure. Trellis for bean and leaf production.
Sudan grass	Sorghum bicolor	Direct sow 2–3 x's desired final density. If cut correctly regrowth occurs 1–2 times/year for 2–4 years.
soybean	Glycine max	Direct sow @ 1plant /6–12". Deep infrequent irrigation. Harvest while green.
perennial peanut	Arachis pintoi	Direct sow cut to keep confined to rows.
vetiver grass	Chrysopogon zizanioides	Transplant clump divisions directly into prepared beds.
lemon grass	Cymbopogon citratus	Transplant clump divisions directly into prepared beds. Divide the clumps when harvesting.
buckwheat	Fagopyrum esculentum	Direct sow seed 6" apart. Best if planted in a mix with Sudan grass, corn, beans, amaranth, etc.
sweet potato	Ipomoea batatas	Burry 6–12" of a 18" cutting in trench in a fluffy bed. Add lots of mulch at regular increments as the plants develop. Performs best in low nitrogen soils.
Guinea grass	Megathyrsus maximus	Direct sow 2–3 xtimes desired final density. If cut correctly regrowth occurs 2-4 times/year for 3+ years.
daikon radish	Raphanus sativus	Direct sow 2 times the desired density. Pull roots before flowering begins or cut and drop.
beach pea	Vigna marina	Direct sow seeds 1/3ft2 and thin to desired spacing or cut at 2–3 months for green manure. Trellis for bean production. Will re-seed if legumes allowed to persist through drying.
cow pea	Vigna unguiculata	Direct sow seeds 1/ft2 and thin to desired spacing or cut at 2–3 months for green manure. Trellis for bean production. Will re-seed if legumes allowed to persist through drying.
beach vitex	Vitex rotundifolia	Transplant rooted cuttings and seedlings into prepared beds. Prune regularly for mulch production and flower promotion. Prefers the coastal strand community.
elephant grass	Pennisetum purpureum	Stick cuttings with 4 nodes - 2-nodes-deep @ ~1m spacing x 15' b/t rows

Short-term crops

This table lists short-term vegetable and herb crops successfully grown throughout the US-Affiliated Pacific Islands. Each species is categorized by the average range of harvest time. Many of the species listed can continue producing long after the listed harvest time. The suggested crops are meant to rapidly cover the area in between the medium and long-term species. Plant them at the typical suggested seeding rate. Be sure to thin around the medium and long-term species so they are not overwhelmed by the short-term crops.

Common Name	Species	30-60 days	60-90 days	90-120 days
amaranth	Amaranthus hypochondriacus		✓	✓
arugula	Eruca vesicaria ssp. sativa	✓		
basil	Ocimum basilicum	✓	✓	
broccoli	Brassica oleracea var. italica	✓	✓	
burdock	Arctium lappa			✓
catnip	Nepeta cataria			✓
cauliflower	Brassica oleracea var. botrytis		✓	✓
celery	Apium graveolens			✓
chayote	Sechium edule			✓
Chinese cabbage	Brassica rapa subspecies chinensis	✓	✓	
collard	Brassica oleracea var. viridis		✓	✓
comfrey	Symphytum officinale			✓
corn	Zea mays		✓	✓
eggplant	Solanum melongena			✓
garlic chive	Allium tuberosum		✓	✓
kale	Brassica oleracea		✓	
lemon balm	Melissa officinalis		✓	
lettuce	Lactuca sativa	✓	✓	✓
Lima bean	Phaseolus lunatus		✓	
New Zealand spinach	Tetragonia tetragonoides	✓	✓	
okra	Abelmoschus esculentus	✓	✓	
spearmint	Mentha spicata			
tomato	Solanum lycopersicum		✓	✓