



Forest Inventory System

User manual

v.1.4

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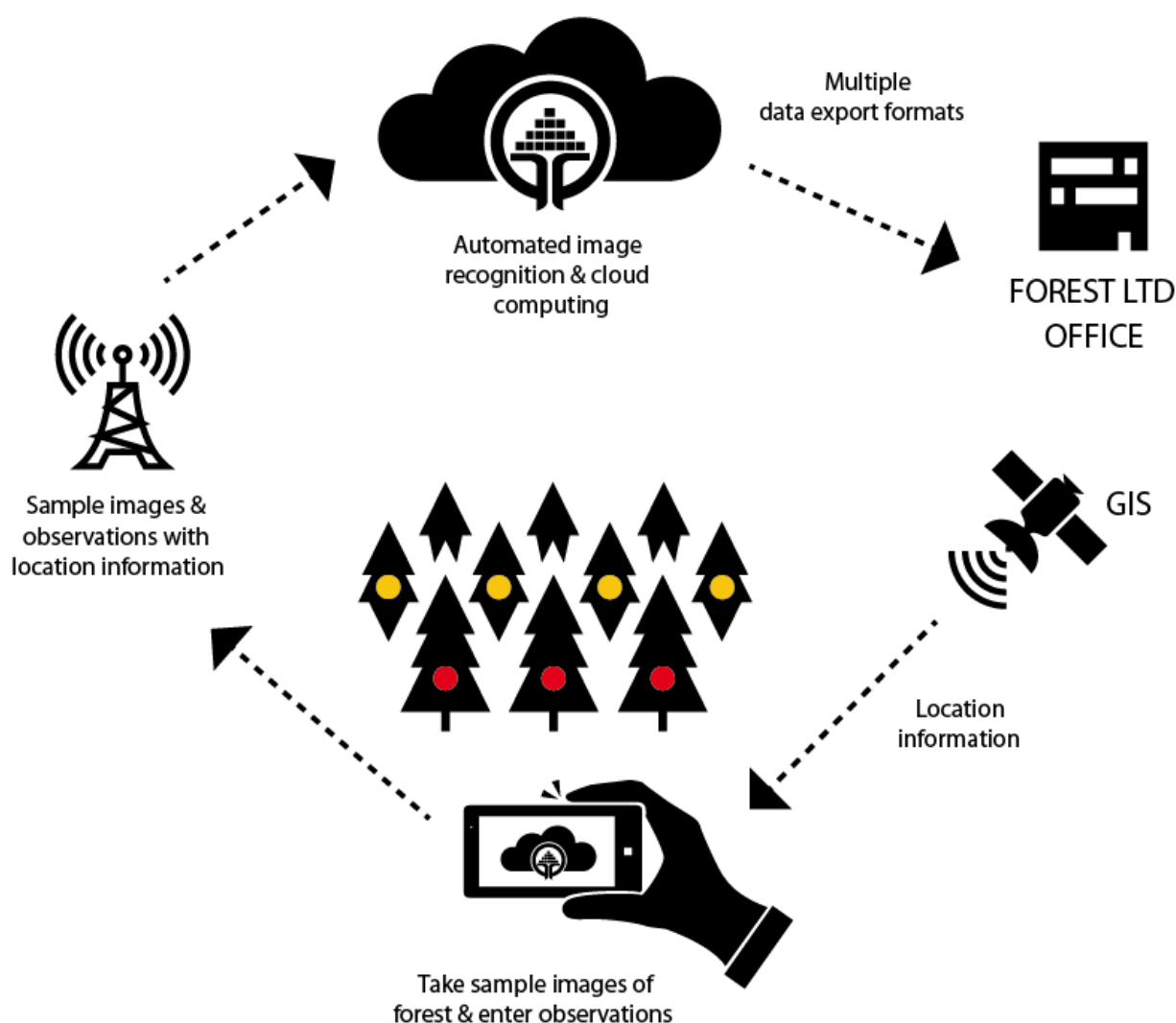
1. Introduction

1.1. How TRESTIMA works?

In short, TRESTIMA measures standing timber and other attributes by shooting pictures in a forest.

In more detail: photos are shot with TRESTIMA –mobile application. As long as Internet connection is available these *Sample pictures* or *Samples* are automatically transferred to TRESTIMA cloud for analysis. Trunk widths and heights as well as tree species from each Sample are then detected and results calculated. Finally the end result is transferred back to the TRESTIMA mobile application.

All the information, including Sample pictures also remains stored in the cloud service. This information can further be transferred to customer's own information systems via different formats (ie. XML or excel) or automatically with the comprehensive APIs provided by the service.



PICTURE 1: HOW TRESTIMA WORKS

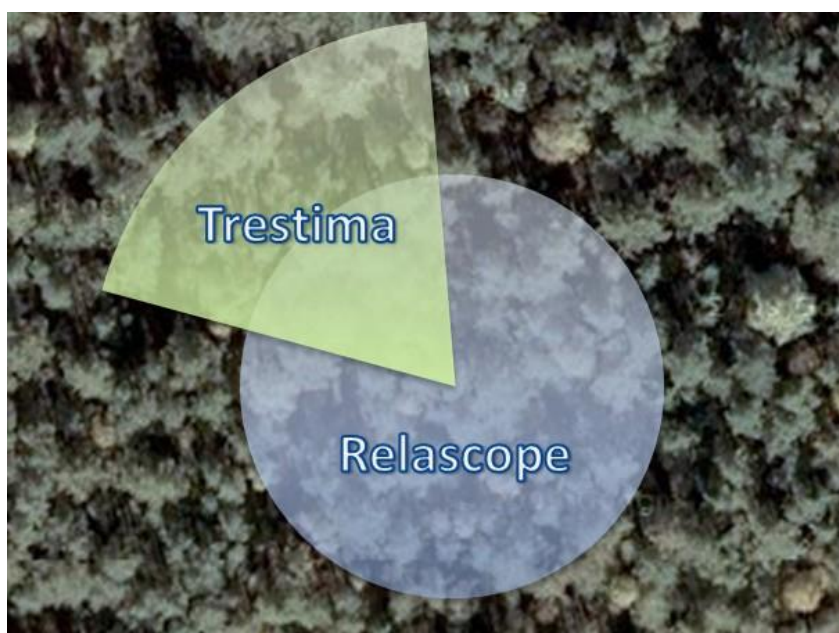
1.2. How TRESTIMA calculates basal area

TRESTIMA's basal area calculation is fundamentally based on the principles of a Bitterlich relascope but instead of physical gauge and a rod Trestima uses a mobile device's camera for measuring basal area. In TRESTIMA, relascope's rod and slot have been replaced with information given by camera's focal length and sensor size. Although the mathematical principle in these two tools is the same the usage of TRESTIMA differs in many respects.

While with a relascope you turn around a full circle counting stems, you simply take just one picture with TRESTIMA. Depending on the mobile device's camera, the picture can represent about 60 – 70 degrees of full circle (i.e. Sony Xperia Z1's angular field of view is ~64 degrees)

Basal area gauge has a fixed basal area factor *BAF* (usually $BAF=1$). This means the number of trunks that fill the slot equals to basal area per hectare in square meters. There is no a fixed BAF in TRESTIMA but basal area is calculated dynamically with factors between 0.6 and 1.4. In order to get the same results with traditional equipment, a measurer should do countless amounts of full circles with a basal area gauge which has adjustable BAF and calculate the average over all of the results.

Because TRESTIMA Forest Inventory System's the smallest "slot" is narrower than the traditional basal area gauge's slot, TRESTIMA also picks up trunks farther than traditional basal area gauge.



PICTURE 2: DIFFERENCE BETWEEN TRESTIMA AND RELASCOPE MEASUREMENT

As is the case with traditional point sampling the place where the picture is taken is also very important with TRESTIMA. In case you only shoot pictures of spots where you see large amount of trees, you'll likely get a high basal area. TRESTIMA measures basal area accurately from the trees visible in the pictures. After a short experience with TRESTIMA it becomes easier to shoot pictures that better represent the forest. This eventually leads to more economical usage of the system as the results are obtained with fewer amounts of pictures.

Some foresters accustomed to using relascope resiliently use TRESTIMA imitating the 360 degree sweep and take several pictures from one point to four opposite directions. While this definitely yields good

results, it is much more beneficial to take all of the pictures in different locations.

This concept is easy to grasp by thinking which gives better estimation of the timber in forest: accurate information from one point or an average of slightly less accurate information from several different spots?

2. Usage in the forest

2.1. Generic workflow of TRESTIMA inventory

The generic work flow of TRESTIMA measurement can be divided into three parts:

1. PRE-WORK

Usually it's a good idea to define the area of interest prior entering the forest. In practice this means either importing the forest parcel (e.g. shapefile) into TRESTIMA web service or drawing the stand/compartments borders with the tools provided in there.

While this is not mandatory and you can assign the sample pictures and observations to a particular stand geometry also afterwards, this greatly helps navigation in the forest and ensures you shoot sufficient number of Sample pictures in each stand.

2. FIELD WORK

Basic field work with TRESTIMA is straight forward - In case you have done the pre-work, it's normally just walking through the area being measured while shooting pictures with TRESTIMA application.

In more advanced use cases the field work may also involve e.g. inputting harvesting and management operations, recording other nature values, assessing quality of harvest, etc.

However the foundation of a good fieldwork is always meticulous shooting of the sample pictures.

3. INSPECTING AND UTILIZING THE RESULTS

Ideally you are ready right after the last Sample picture is taken or observation recorded. However it's generally a good idea to log in to the TRESTIMA web service (www.trestima.com/trest/estima/login/) and visually inspect the newly made measurement session and address any issues you might encounter. Potential issues might include e.g. Sample pictures that need to be moved to a different stand or disabled from calculation altogether if they are for example taken outside of the stand, making sure all species have height recorded and input one if missing, etc.

Once you are satisfied that the measurement session is looking like you intended, you are ready to utilize the results as best suited.

2.2. Measuring basal area by shooting pictures



Basal area (BA) measurement with TRESTIMA is done by capturing sample images from the forest evenly throughout the stand. We recommend shooting at least 10 sample image in each stand.

The proper way of measuring a single stand with the size of few hectares is to circle the stand close to its borders but still well within the forest and shoot pictures with steady intervals roughly towards the center of the stand. If the measured area is large (>2 hectares), shoot pictures also in the center.

To capture a BA image do the following:

1. Pick the place and direction for the image being captured
 - When picking a proper plot, you can use the application's map as a guide – choose a location where no images have previously been captured.
 - If you are close to the stand borders, make sure you capture the image to a direction that belongs to the stand being measured.
 - Capture the image to a direction that has good visibility; BA of the sample might be lower than real in case the image is blocked by a nearby large trunk or impenetrable bush.
 - When operating on a sunny weather try to capture images with the sun behind you back avoiding direct bright sunlight towards camera.

2. Capture the BA image

- Press the camera icon  on the lower right corner of the screen to open the viewfinder.
- Point the camera towards the desired shooting direction in horizontal orientation.
- Press the camera icon  on the right side of the screen to capture the image. Continue holding the device steady until you hear a “bing” sound and see the post capture view of the image
- Captured sample image is now shown in the screen for few seconds depending on your settings. At this point you can still discard the image by pressing the “X” –symbol.
- You can now move on to the next spot. The sample image is automatically stored to the device's upload queue and will be sent to the TRESTIMA server for analysis when network connection is present.

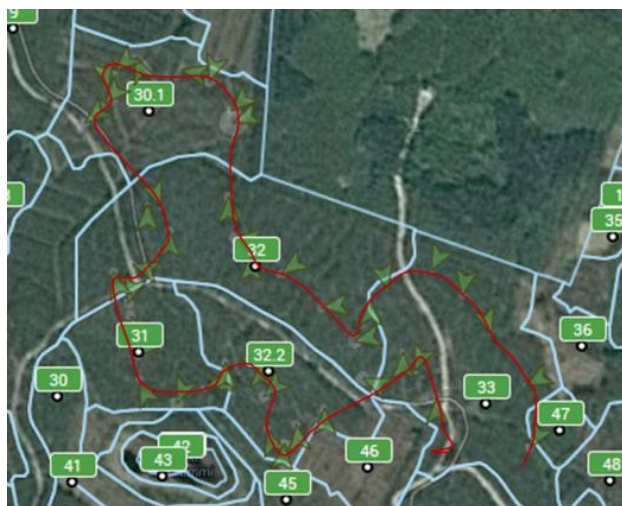


PICTURE 3: CAPTURING BASAL AREA

2.3. Working on a forest parcel

When surveying multiple stands it is important to plan your route in beforehand to optimize the time spent in the field. It might not always be feasible to circle every stand as illustrated in the previous chapter. Therefore you should plan your walking route so that every stand gets covered with as few walking as possible. Picture 4 gives an example of an efficient planning of route through a parcel. Green arrow represents captured BA images. Notice how the same stands are visited several times from different locations as the forester moves in the parcel. This ensures efficient and even sampling.

After an image has been captured the result is usually visible after a minute or two. In cases of bad network coverage the results become visible only few minutes after the upload queue has been emptied. In very remote locations this might require bringing the device e.g. to an office building where internet connection is available through WLAN. Also in forest areas with rare or unknown species to TRESTIMA the final result might be available only during the next working day as manual work might be needed to reach the proper detection of species. For these scenarios TRESTIMA has human operators aiding the machine vision when necessary. This is to ensure same good quality in virtually every condition. Besides the delay the process is invisible to customer.



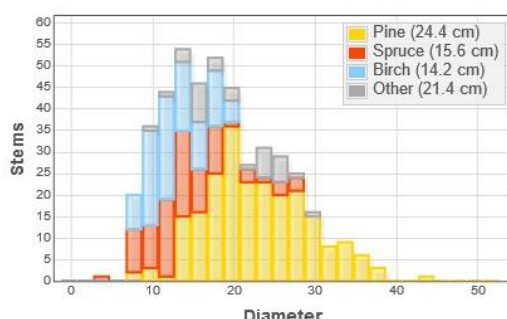
PICTURE 4: SURVEYING A PARCEL (IMAGE FROM THE WEB TOOL)

2.4. Amount of pictures needed in a stand

As a rule of thumb we recommend to take at minimum of 10 pictures in each stand.

More pictures should be taken when 1) forest is sparse, 2) forest is uneven or 3) forest is young with average DBH less than 12 centimeters. In these conditions the sample size from a single picture is often only few trunks. Hence the overall sample size need to be increased by taking more pictures.

TRESTIMA also calculates an automatic breast height distribution chart for each species. As is true with all measurements done with TRESTIMA also this chart becomes more reliable the more pictures are taken. We recommend at minimum of ten pictures taken before using the chart in operational decision making.



PICTURE 5: PROFILE OF A NATURAL FOREST STAND IN FINNISH LAPLAND

3. TRESTIMA Mobile Application

3.1. Installing the software

TRESTIMA application for Android devices can be downloaded and installed through Google Play Store.

TRESTIMA application for iOS devices can be downloaded and installed through Apple iTunes.

Android:

Do the following:



- 1) Open Google Play Store from your device by clicking the icon:
- 2) Click the magnifier glass –symbol to initiate search
- 3) Type in “trestima” to the search field and select the found TRESTIMA –application
- 4) Select “Install”
- 5) Follow the instructions on the screen throughout the installation process. You need to give TRESTIMA permission to access e.g. device’s GPS as this is needed by the application to work properly.

iOS:

Do the following:

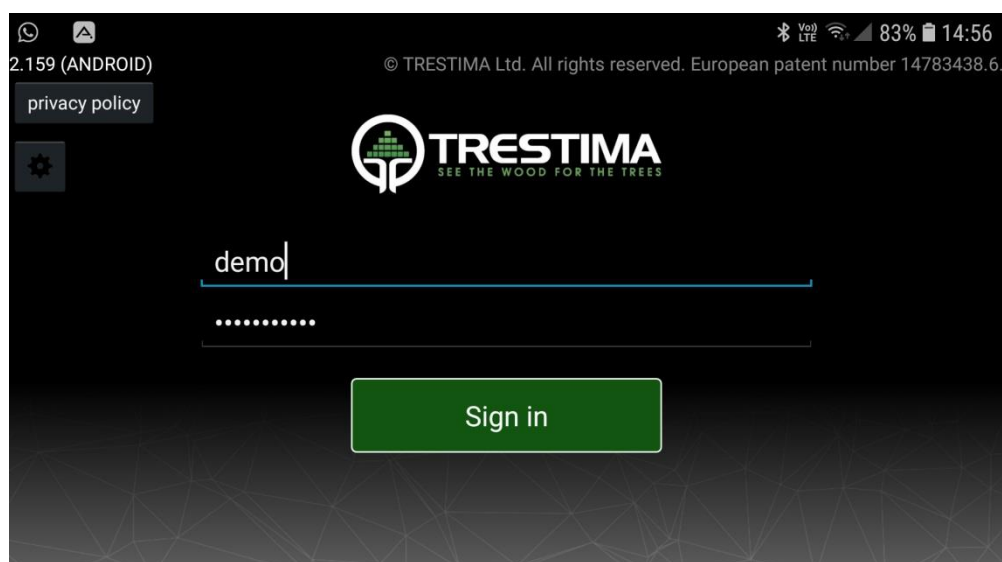


- 1) Open App Store from your device by clicking the icon:
- 2) Click the magnifier glass –symbol to initiate search
- 3) Type in “trestima” to the search field and select the found TRESTIMA –application
- 4) Select “Install”
- 5) Follow the instructions on the screen throughout the installation process. You need to give TRESTIMA permission to access e.g. device’s GPS as this is needed by the application to work properly.

3.2. Launching the application



- Launch TRESTIMA by clicking the icon:
- Application opens and asks for credentials (Picture 6).
- Type in you TRESTIMA –credentials and press “Login”. In case you don’t yet have credentials please contact sales@trestima.com or create your own for free at www.forestmeter.com



PICTURE 6: LOG IN SCREEN

In case this the first time you login to the application, a working network connection is required. After the first successful login you can login also in offline conditions.

Notice the settings-button on the upper left hand side of the login screen. This opens the maintenance and settings menu where user can adjust parameters such as post capture preview time, number of cached parcels, etc.

3.3. Main view of the application



PICTURE 7: MAIN VIEW OF THE FIELD RECORDER

After a successful login the application opens into main view.

1. Name or number of the active stand.
2. Selection of active parcel or working area.
3. Username.
4. Input for tree heights, widths and other data for stratum.

5. Input for free textual notes and image notes.
6. "Own position": centers map to your own position
7. Own position on a map. Arrow indicates walking direction and the outermost circle represents current GPS quality.
8. Map layer selection.
9. Toggle capturing of a trail.
10. Drawing tools.
11. Button for capturing *Sample Images*.
12. Upload queue: shows number of images and inputted data objects to be uploaded to the server.
13. Result button: shows real time basal area and error if available. Pressing the button opens result view.
14. Map. Pan&zoom with sliding and pinching.

3.4. Selecting working area and active stand

While in the main view, press button 2 to choose desired working area/parcel. The application shows list of parcels imported into TRESTIMA –web service (See chapter 6.1). After selecting a parcel, the application downloads stand borders to device's local memory allowing also future offline usage. Please note that if there are no parcels uploaded to the TRESTIMA web service, this list is empty.

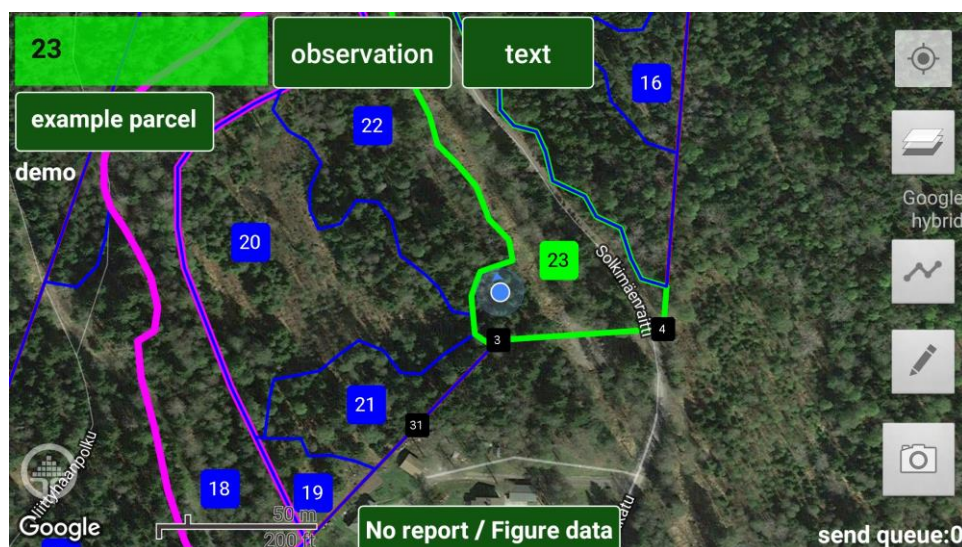
Please refer to chapter Naming the active stand on how to name the stand and measure forest without predefined stand borders.

NOTE: It's advisable to select the working area already while at the office in case of bad or no network coverage in the field.

3.4.1. Active stand

Active stand is shown in map with a different color. Active stand is automatically selected based on your own position in the field allowing you to simply walk and shoot pictures while in the field. You can also force an active stand by tapping its name.

All captured images and inputted data are by default assigned to the active stand unless user has manually selected another stand before shooting a sample picture or recording an observation.



PICTURE 8: ACTIVE STAND

3.4.2. Naming the active stand

When measuring forest area without existing stand borders, you can simply give it a name and start shooting pictures.

To do this tap the stand name –box at the upper left corner in main view (button 1). Next, type in a name or number for the stand. You can now shoot pictures and input data for the stand.

As TRESTIMA doesn't know the size of the area of the stand, results are given in relation to one hectare.

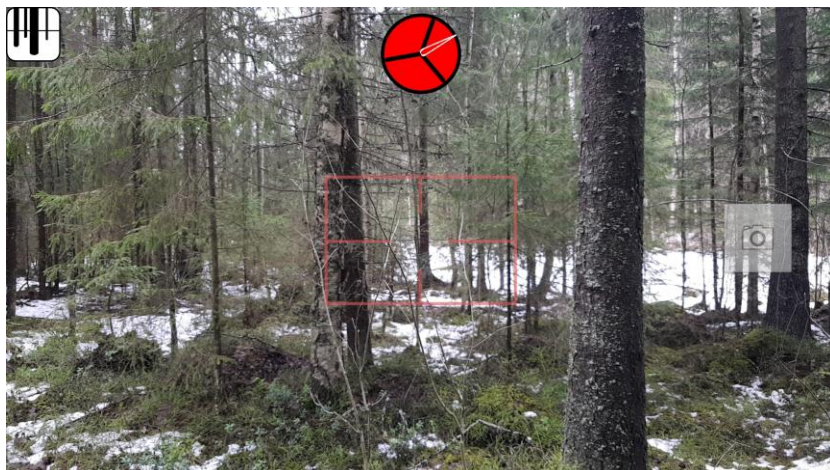
You can define the area later in the web tool by importing or drawing the stand borders yourself and moving the sample images to the newly imported/created parcel. For detailed instructions please check our instructional videos on the TRESTIMA-youtube channel.

3.5. Shooting Sample pictures

Please refer to 2.2 for generic instructions on how to shoot Sample pictures.

Press button 11 to shoot a Sample image. Camera activates and viewfinder's image is visible in the screen.

- Hold the device in landscape orientation and you should see the icon on the top left corner of the screen to illustrate that you are now shooting a basal area sample (see Picture 9: Shooting a sample image without following the direction guide).
- The indicator in the top of the screen is called *direction aid*. It has three predetermined directions. Turn the phone until the indicator turns green (see Picture 10). It doesn't matter which one of the three directions you choose. NOTE: while usage of the direction aid is not by default enforced, it helps to achieve more objective results as the shooting direction is not decided by you.
- Shoot sample pictures directly towards the horizon. Avoid tilting the camera upwards or downwards.
- In case of steep hills, shoot pictures parallel to hill avoiding high angles that cause the pictures to be automatically discarded.



PICTURE 9: SHOOTING A SAMPLE IMAGE WITHOUT FOLLOWING THE DIRECTION GUIDE



PICTURE 10: SHOOTING A SAMPLE IMAGE TO PROPOSED DIRECTION

3.6. Inputting tree heights and diameters

TRESTIMA automatically extracts median diameter for each species from the images taken. This number is used by the system when calculating the amount of trees per hectare.

TRESTIMA also tries to determine the corresponding height for each species by utilizing the data it has of previously measured similar forests. Especially in areas where TRESTIMA is not yet widely used the height might not be available. In this case user has to either type it in using the *observation* –button (button 4) or measure it using TRESTIMA –yardstick as described in chapter Measuring median trees.

aspen, 16 cm, 17 m			Image	Send
specie	diameter	height	BA (m ² /ha)	Log %
pine	15 cm	15 m	25	55 %
norway spruce	16 cm	16 m	26	60 %
birch	17 cm	17 m	27	65 %
aspen	18 cm	18 m	28	70 %
other	19 cm	19 m	29	75 %
larch	20 cm		30	80 %
Stand: 22			BA: 37.4 m ² , Std. error: 15.4%	

PICTURE 11: INPUTTING DIAMETER AND HEIGHT FOR ASPEN

In any case both diameter and height can be manually inputted by pressing the *observation* –button from the main view. The process goes as follows:

- 1) Press the observation button
- 2) Select the species
- 3) Select the diameter and/or height from the scrolling list
- 4) Press “Send” button when ready

The width/height observation is now stored and will replace any value automatically calculated by TRESTIMA.

In case of several observations or yardstick –measurements are done for the same species, TRESTIMA uses an average over all the inputted values.

3.7. Inputting free text and images

Press button 5 to input free textual observations with optional images.



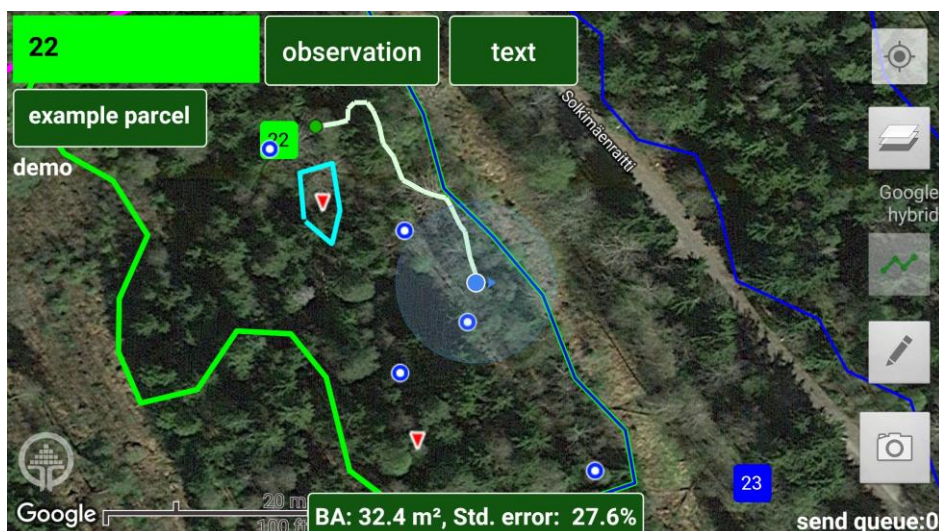
PICTURE 12: INPUT FOR FREE TEXT WITH AS OBSERVATIONAL IMAGE

- Type in text + press send -> Textual observation is recorded for the active stand.
- Type in text, select "image", capture image + press send -> Text with an image observation is recorded for the active stand.
- Select "image" + press send -> Image observation is recorded for the active stand.

NOTE: Observational images and texts have no effect to the results of the stand. This functionality is provided for easy storage and association of notes and images to a stand. In a later phase these notes can provide you with valuable information when further analyzing and refining the forest data.

3.8. Capturing a trail

Press button 9 to start trail recording. The application now draws the path you are walking to the map. Recording of the trail continues in the background even if the phone's screen is switched off or the application is placed on background. To finish the recording, press the button again. Trail is now stored and is visible also in the web service. Note that the feature requires decent GPS signal to work.



PICTURE 13: CAPTURING A TRAIL

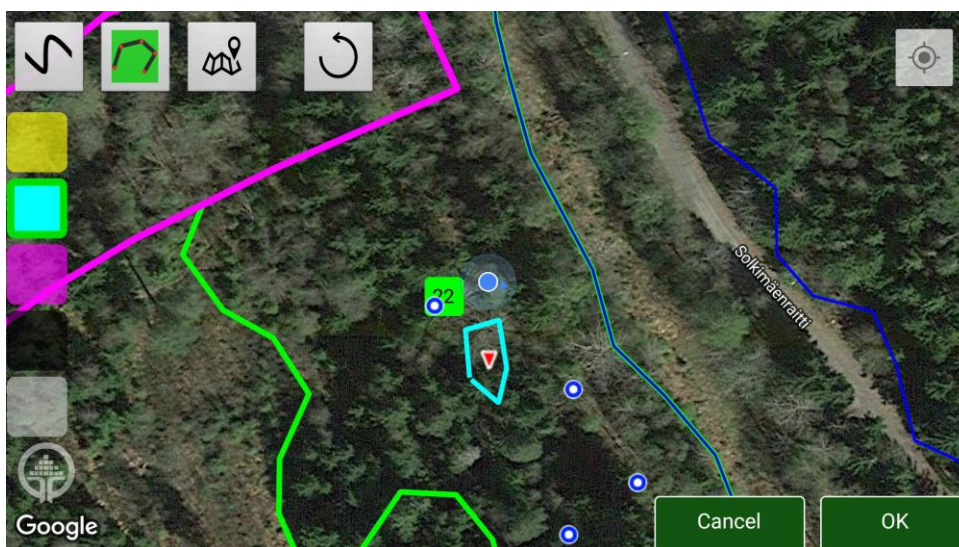
3.9. Drawing tools

The drawing tools of the application are intended to be used for recording observations in the field that are best expressed by drawing on top of a map. These can include e.g. the following:

- Marking a specific feature like spring, pond or path that is not visible on a map.
- Planning modifications to the stand geometries, like combining and splitting current stands.
- Assigning complex instructions like specific inventory areas to a multi person field crew.
- Planning harvest site logistics by drawing road side storages, turning points, etc.

You can start drawing your plans by pressing button 10 from main view.

NOTE: Drawings don't impact the inventory results in anyway nor do they impact the stand geometries.



PICTURE 14: DRAWING INDICATING THE POSITION OF A SMALL POND OTHERWISE NOT VISIBLE ON A MAP

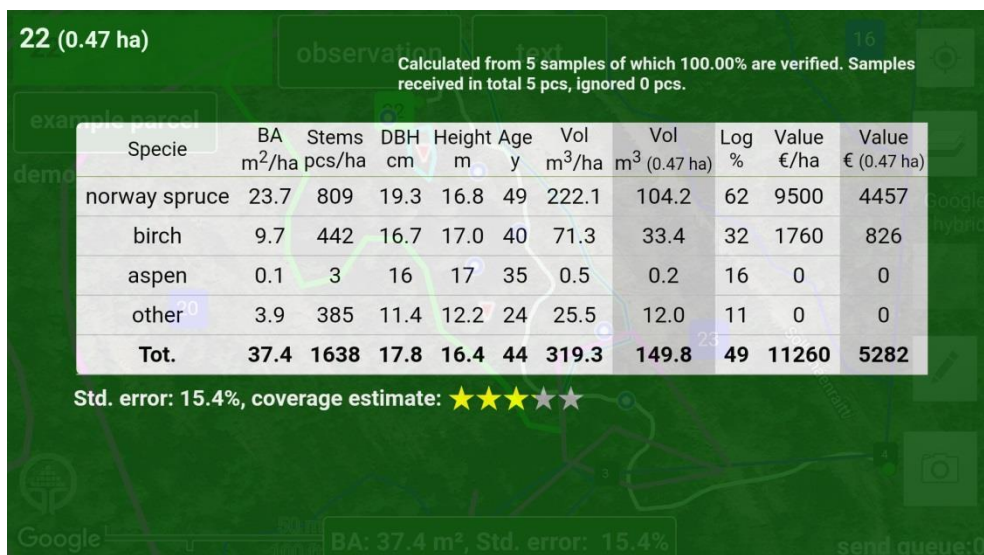
Please visit TRESTIMA YouTube channel to see in depth instructions on how to use the feature.

3.10. Inspecting the results

While in the main view, press button 8 to get a more detailed overview of the inventory results.

The result page (Picture 15) shows results for each species separately. Flicking the screen to the right brings visible the listing of inputs made to the stand. Flicking to the left shows information associated to the parcel (if available).

3.10.1. Results view (center view)

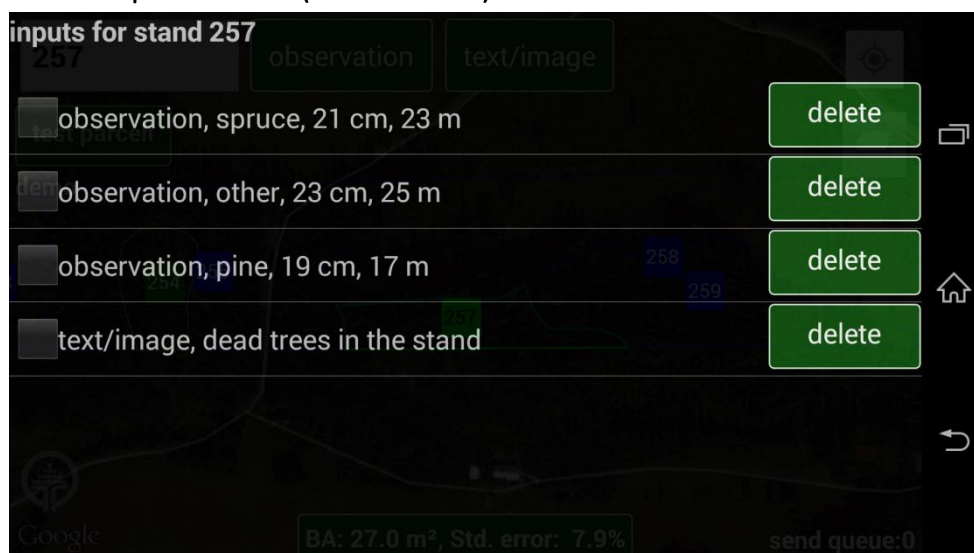


PICTURE 15: RESULTS VIEW (WITH MARKET VALUE)

- Information shown is based on the captured images and inputted tree width&height data which have been sent to the TRESTIMA web server and calculated online. In case there are items in the send queue that information is not included in the results.
- Result view can be tailored to show customer specific information. This information can include e.g. market value of timber products (Picture 15: Results view (with market value)), yield prediction of harvest or thinning operations, assessment of log quality, etc.

Scroll the screen to the left to see a list of notes and data you have inputted.

3.10.2. Inputted data (leftside view)



PICTURE 16: INPUTTED OBSERVATIONS

- You can delete the items from this view by selecting "delete" next to the item.

3.10.3. Parcel data (rightside view)

Scroll the screen to the right until you see information associated to the parcel on a white background. The information is shown as it is when importing to TRESTIMA. The view is only visible if imported parcel contained such data that could be parsed by the service.

Kuvio	Pinta-ala	Pääryhmä	Alaryhmä	toimenp.	Kasvupaikkal.	Maalaji			
42	6.5	Metsämaa	Kangas		Kuiva kangas, vastaava suo ja varputurvekangas	Kallio tai kivikko			
Kuivatus	Aika oj.	Kehitysl.	Metsikön laatu	Pääpuulaji	Saavutettavuus	Pvm			
Ojittamaton kangas	0	Nuori kasvatusmetsikkö	Kehityskelpoinen, hyvä	Mänty	Myös kelirikon aikana	01.01.2014			
Osite	Jakso	Ikä	PPA	Runkoluku	Läpimitta	Pituus	Puulaji	Tukki-%	
1	1	27	8.5	0	9.4	9.3	Mänty	0	
2	1	27	1.1	0	9.2	9.8	Kuusi	0	
3	1	22	1.1	0	9.8	14.3	Rauduskoivu	0	
4	1	22	0.5	0	9.5	13.6	Haapa	0	
K-a/yht.		26	11.2	0	9.4	10.0			
Hakkuuv.	Tapa	Kiire	Lisä1	Lisä2	Hoitov.	Työlaji	Kiire	Lisä1	Lisä2
1	Ensiharvennus	6-10 v.	0	0	1	Taimikonhoito	1-5 v.	83	0
2	Ensiharvennus	6-10 v.	0	0					

Osin taimikkoa. Kuvion länsiosassa puuryhmien perkausta.

PICTURE 17: PARCEL DATA

- This view is read-only.
- The data is shown in the format it was imported to the system.

4. Measuring median trees (optional)

In normal operating environment TRESTIMA can accurately measure diameters of the trees visible in the Sample pictures and predict the corresponding heights from history data. However in some operating conditions this data is not available and needs to be measured manually. These conditions can include e.g. the following:

- System is used in a new geographical area from where history data hasn't yet accumulated to the service.
- System is used in a forest with species that are not *known* to the system.
- Too few sample pictures taken.

In the above mentioned situation, median tree must be measured manually. This can be done either with conventional tools (hypsoneter, vertex, etc) and inputting the values into TRESTIMA as described in chapter 3.6 or measurement can be done with TRESTIMA using a yardstick.

Measurement of a median tree begins by selecting one or more trees of each species that best represent the average size of their species. After a suitable tree is found, TRESTIMA yardstick is attached to the trunk and the tree is photographed for width and height measurement separately.

4.1. Choosing a median tree

Selecting a right sized median tree requires professional eye and experience especially when surveying a forest with large diversity. With TRESTIMA, several trees of same species can be measured and the system automatically uses the average of these measurements. This makes it easier to pinpoint the proper width

and height of each median tree. It is recommended to measure 2-3 trees for each species to reach an objective result for median tree.

4.2. Usage of TRESTIMA yardstick

After a suitable median tree has been selected TRESTIMA yardstick is attached to tree by pushing the spike into the tree's bark. The upper edge of the stick must be at 180cm height from the root.

It is advisable for the person committing the survey to measure in beforehand where the 180cm level is subjective to his/her own eye level. This makes it easy to attach the stick to a proper height without having to measure the distance from the ground.



When attaching the yardstick pay attention to these details so that both width and height images can be captured without having to move the stick:

- Make sure that the height image can be captured
 - Both treetop and yardstick have to be fully visible in the picture taken from 10-20 meters distance.
 - Height picture can be captured standing in the same level as the tree root.
- Images don't have to be captured towards direct sunlight which can "burn" the images.



PICTURE 18: ATTACHING TRESTIMA YARDSTICK

4.3. Measuring width with TRESTIMA yardstick

1. Make sure the yardstick is attached to tree trunk at 180cm height measuring from top of stick to the root.
2. Position yourself roughly 1.5-2m away from the tree.
3. Press the camera icon  on the lower right corner of the screen.
4. Hold the phone in an portrait orientation and on a parallel level to the middle of the stick (as in Picture 19), Make sure that the yard stick is fully visible in the viewfinder and is symmetrically positioned in the picture.
5. Hold the phone steady and press the camera icon  on the bottom of the screen.
6. Captured image is shown in the screen for few seconds. At this point you can still discard the image by pressing the "X" -icon.



You can now move on to capture next sample – the picture is stored to device's sending queue and will be automatically sent to Trestima cloud for analysis.



PICTURE 19: MEASURING WIDTH

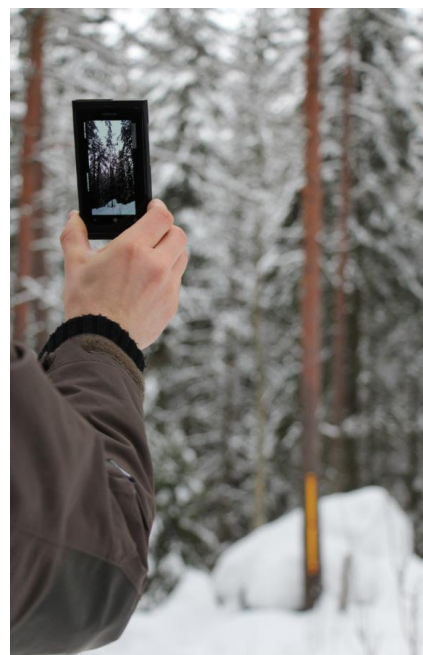
The sample is shown in the map with a symbol.

4.4. Measuring height with TRESTIMA yardstick

1. Position yourself roughly 15-20m from the yardstick
2. Press the camera icon  on the lower right corner of the screen.
7. Hold the phone in portrait orientation and point it toward the middle of the trunk (see Picture 20). Make sure both the yardstick and the top of the tree are visible in the picture.
8. While holding the phone steady, press the camera icon  on the bottom of the screen.
3. Captured image is shown in the screen for few seconds. At this point you can still discard the image by pressing the “X” –icon.

You can now move on to capture next sample – the picture is stored to device’s sending queue and will be automatically sent to Trestima cloud for analysis.

The sample is shown in the map with a symbol.





PICTURE 20: CAPTURING HEIGHT

5. Measuring area in the woods (deprecated)

Trestima allows users to tag area corner points in the field by shooting downwards.

To tag an area corner point, do the following:

1. Press the camera icon  on the lower right corner of the screen.
2. Hold the phone steady on top of the chosen corner point so that the camera lens points directly downwards.
3. Press the camera icon  again to capture the corner point.
4. Captured image is shown in the screen for few seconds. At this point you can still discard the image by pressing the “X” –icon.

The corner point is now stored and indicated in the map with a symbol.

NOTE: When calculating result in TRESTIMA web service only the images within the tagged area are included. In the mobile report all images are always used in the result.

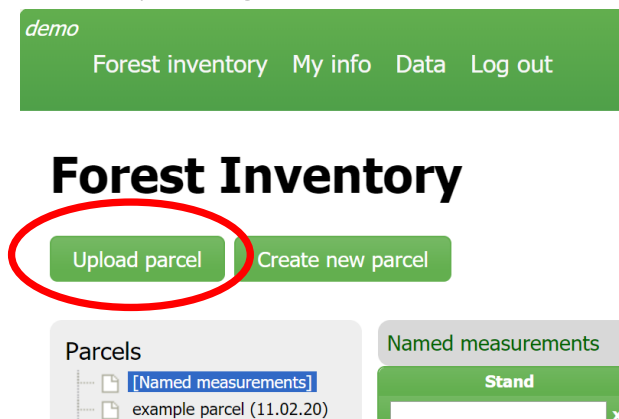


PICTURE 21: CAPTURING AREA CORNERPOINT

6. Using pre-defined stand borders in Trestima

Pre-defined stand borders can be uploaded into TRESTIMA web service in various formats. After this is done, stand borders become automatically visible for the mobile application as well.

6.1. Uploading stand borders to TRESTIMA web service



PICTURE 22: UPLOADING PARCEL TO TRESTIMA WEB SERVICE

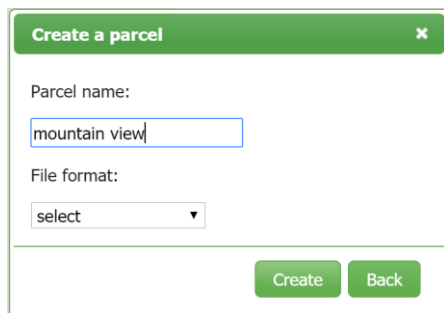
1. Log in to Trestima with your credentials at: www.trestima.com -> Customers -> Login
2. Press the "Upload parcel" –button
3. Select the format of your forest geometry files
4. Give parcel a name the parcel
5. Choose the proper files for upload with the "Browse" –button.
6. Start the upload with the "Send" –button.
7. Wait until the upload finishes. For large parcels (> 100 stands) this can take up to ~10 seconds.
8. After the upload is finished return to "Forest inventory" page to see your newly imported stands.

You can inspect single stands from the list on the center of the screen or the parcel as a whole through the link below the Forest Inventory- title.

6.2. Creating a new parcel

Instead of importing a parcel you can also draw it on top of a map with the tools provided in the web service.

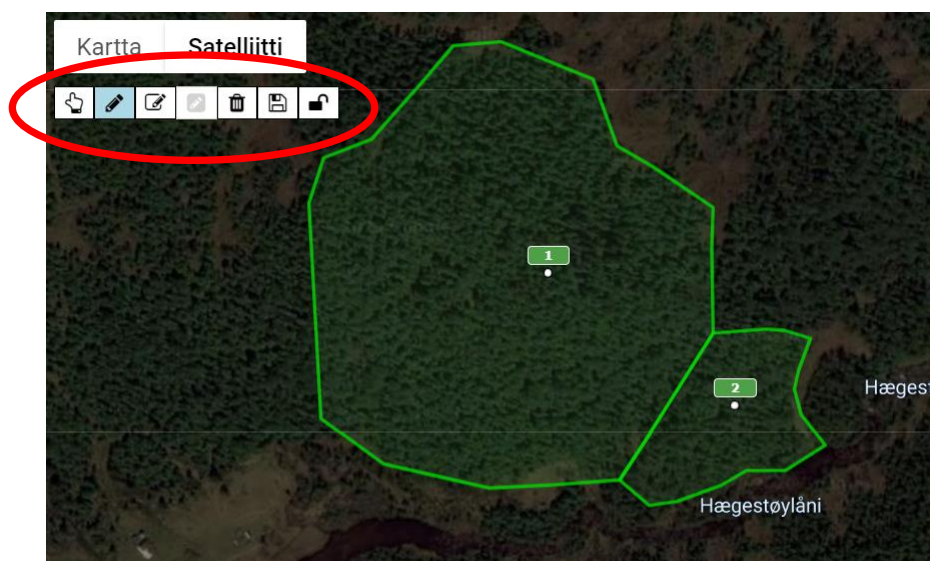
Select "Create new parcel" on the main view. Give a name for the parcel and press "Create".




PICTURE 23: NAMING A PARCEL


Using the map, browse to the area that you are interested of and use the provided drawing tools to draw the stands (see Picture 24).

Please check out TRESTIMA YouTube page for detailed instructions on how to use the drawing tools.



PICTURE 24: DRAWING NEW STANDS/PARCEL WITH DRAWING TOOLS

After each drawn stand, make sure to save your modifications by pressing the -icon.

Finally lock the drawing tools by clicking -icon and you are ready to start your field work – Newly created parcel is immediately visible in the mobile application.

7. Troubleshooting

Our customer support is reachable during regular office hours. E-mails are answered within three business days.

E-mail: support@trestima.com

Phone: +358 40 4846500

www.trestima.com