APSIM Training Exercises for Plantation Forestry

These training exercises are accompanied by a collection of associated screenshots in the file *APSIMForPlantationForestryInstructionsExercisesScreenShots.*
You might not exactly create the values and colours in graphs as shown, but the main aim is to build, run and graph simulations successfully, i.e. the simulations should run as planned and without error messages.
Contact Philip if something is unclear (+61 409 242 677, Philip.Smethurst@csiro.au) and if you have suggestions for improving these training instructions.

Files provided for saving in the same folder as your simulations:

Exercises:

- APSIMForPlantationForestryInstructionsExercises (these instructions)
- APSIMForPlantationForestryInstructionsExercisesScreenShots (open, and follow it with the following exercises)

Essential for simulations during the exercises:

- lincoln.met
- WarragulCO2.met
- ObservedDataForPlantationForestryTraining.xlsx

Optional Reading

- Parameters-for-soil-water-Ver20-190815.pdf
- Methods-for-PAWWRC-estimation_DNRME.pdf
- Soil matters.pdf

1. Tour the website	a. Go to the website www.apsim.info. Visit the various tabs to generally familiarise yourself with the type of content in each. Especially look at: b. Click on the Download tab, and further downloading instructions are provided in Exercise 3 below. c. APSIM Next Generation/Model documentation: https://apsimnextgeneration.netlify.app/modeldocumentation/ d. Demonstration videos: https://www.apsim.info/support/videos/, including four for Eucalyptus plantation forestry.
2. Understand the General Use Licence	a. Read the summary of the General Use Licence option at: https://www.apsim.info/download-apsim/general-use-licence-summary/, which we is free and the licence needed for these exercises.
3. Download APSIM Next Generation	a. For these training exercises, we will be using version APSIM Next Generation. After clicking on the Download tab of the website, click on link ‘Click here to download or upgrade APSIM’, or use this link: https://registration.apsim.info/ b. Enter your email address. c. Enter details for the page ‘APSIM Initiative Product Registration’ and the page call ‘APSIM Downloads’ d. Choose product ‘APSIM Next Generation’ and Release Number 2024.03.7419.0. You might need to increase the number of rows shown at the bottom of the page to find this number. By using this release number, you will more exactly reproduce the screenshots provided for these training exercises. If you choose a more recent release, e.g. the

	latest (top) one, most screenshots will be the same or similar, but some might be quite different depending on what upgrades have been incorporated since the screenshots were generated for these exercises. e. Here, make sure at 'Version:' you select the Next Generation version that suits your system (i.e. Windows, Debian or Mac). f. You might be sent an email with a link to click on to fully register and commence the download. g. You may be asked to instal Windows Desktop Runtime, if it is not already available on your computer, and this might require administrator permission. If so, accept and proceed. h. Where you have the option to instal for all users or yourself, choose yourself, unless you already have administrator rights on your computer. i. Other than that, choosing defaults is fine by clicking on 'Next'. j. When the installation is complete, open the software to view the graphical user interface (GUI).
4. Tour the GUI	a. Click on each of the tabs of the GUI to see what they offer, but you can ignore the tabs 'Open APSIM file' (as you have not generated any yet in these exercises), 'Importing old .apsim files' and 'View Cloud Jobs'. b. *Homework optional training:* In the *Training toolbox*, in the 'Completed Simulations' folder, the tutorial simulations (Exercises 1-4) provide basic and general training in APSIM Next Generation, which approximately follow those for Exercises 1-5 of the Introductory Training Manuals for APSIM Classic (https://www.apsim.info/support/apsim-training-manuals/). However, currently there is no similar training manual for APSIM Next Generation. Instead, video guides for APSIM Next Generation are available at https://www.apsim.info/support/videos/; under the heading 'APSIM Next Generation, with examples from Eucalyptus plantation forestry' you'll find four training videos more relevant to plantation forestry. c. Once you have completed the following exercises 5-21 (below), we recommend using the Upgrade option frequently to make sure that you are using the latest release, as there might have been important changes to the models or the GUI since your previous upgrade. New upgrades (releases) are approved and released often on a daily basis. Although many changes will be to models that don't affect your simulations, or to the GUI appearance or function, some might be. Hence, it's best to be safe and upgrade frequently. This is part of the continual (small) improvement nature of the APSIM framework, rather using infrequent, major version releases.
5. File locations and types	a. Essential file types for one simulation: (1) .apsimx, which is the main simulation file, which can contain more than one individual simulation. (2) .met, which is the daily weather file. Each simulation needs one met file, which must cover the duration of the whole simulation. b. Optional file: .xlsx, which contains observed data c. Generated file types, which you don't need to look at or understand: .db, .db-shm, and .db-wal are database files, .bak is a backup file. These

		generated files are not necessary to run a simulation, as they will be generated or overwritten during a run. d. Using SaveAs, you can direct the GUI to save your simulation (.apsimx) to a particular location. A local drive will work fastest, but cloud locations can also be used satisfactorily if you have good connectivity. e. .met and .xlsx files do not necessarily have to be in the same folder as .apsimx files, but doing so helps keep all the relevant files for a simulation in one place.
6.	**Run an example**	a. **START A NEW SIMULATION:** Open the EucalyptusRotation example b. Save it to a location on your computer c. Run it either by right-clicking over the top 'Simulations' node, or clicking on the 'Run' icon of the GUI. d. View it at various levels (nodes) of the structure of the simulation nodes, e.g. Memo, Weather, Clock, Summary etc. e. Note the progress bar at the bottom of your screen. This is also where error messages will appear. It's optional to clear those messages by clicking on the 'Clear Status' tab of the GUI.
7.	**Tips for using the GUI**	a. **CONTINUE WITH PREVIOUS SIMULATION:** Right clicking on any node provides context-sensitive options, e.g. Run, Rename, Copy, Paste, Enable/disable, Empty Datastore, Refresh, Export, and documentation options. b. Hovering your mouse over a node shows in a black box the type of node it is called in APSIM, but it might appear by a different name without hovering the mouse if it has been renamed. c. Organise your simulation stack into a sequence that makes sense for you by moving nodes up or down using Ctrl-<up/down arrow>, and rename them if it would be more meaningful. d. The Map indicates the locations of all the met files used in the simulation. A map can be added by right-clicking on the Plantation node, finding Map, and double-clicking. e. Use only numbers, letters and spaces when renaming a node.
8.	**Error messages, unexpected behaviours, Summary node, Support**	a. **CONTINUE WITH PREVIOUS SIMULATION:** Building simulations always involves copying a previous simulation (e.g. an example) and iteratively adding or modifying components, realising it didn't run at all or completely as intended, and working towards resolving problems. b. Error messages are often produced in red at the bottom of the GUI. These can be difficult to understand, but can provide key words about where in your simulation the problem is occurring, e.g. in a Report, or in Soil Water. There you might also find an indication of what was wrong, e.g. the model and report variable is not recognised if you are running a Eucalyptus model but the report refers to a Pinus model, or a <plant>Soil node is not included at Soil.Physical, where PinusSoil might exist, but you actually need EucalyptusSoil. c. In the error message shown in the screenshot, an attempt was made to report a Pinus variable, without a Pinus model being present in the simulation, as this simulation uses the Eucalyptus example. d. The Summary node can also provide insights into how your simulation ran and where a problem occurred.

	e.	No error messages might have been produced, but the run might not produce any results. Perhaps by error your planting date is outside the date window of the Clock, or nitrogen or water stress levels are so high that the plant failed to grow at all.
	f.	An option might be to abandon the changes you made, perhaps by using the Undo option of the GUI, or by going back to a previous version of the simulation. The latter can be facilitated by using a version control system, e.g. OneDrive, or your own periodic SaveAs and renaming system.
	g.	Ask someone else for help. Working with similarly or more experienced users can provide a source of help, e.g. email them the files, explain the problem, and ask for help.
	h.	Use the Training and Support options at https://www.apsim.info/support/
9. Modify an example	a.	**CREATE A NEW SIMULATION:** Copy the EucalyptusRotation example that you have to the top Simulations node. Also copy the graphs to this top level, then, in the copied simulation **'EucalyptusRotation1'** modify the following b-k one at a time, rerunning the simulation in between changes.
	b.	Weather: Weather to lincoln.met
	c.	Clock: Change Clock start date to 30/3/1995. Note that some computers work on different date-time formats that might require you to enter this date in a different format, and it might also affects dates elsewhere in a simulation.
	d.	Management: In TreeManagament, change within row spacing to 1 m
	e.	Change Cultivar to nitens
	f.	Change Planting date to 1-may
	g.	Change Amount of fertilizer N to 200 kg/ha
	h.	Soil: In Soil/Organic, change Soil Organic C (%, 0-10 cm) to 1.5
	i.	By trying a few different fertilizer rates and soil C concentrations, you should see sensitivity to N availability in the various graphs.
	j.	Tip: Copy-pasting individual or blocks of values is possible, e.g. copy all Soil/Physical/AirDry to Eucalyptus LL
	k.	Climate: What sensitivity would there be to a drier climate? How could you test that?
	l.	Again, copy, paste (or drag) the individual (child) simulation called '**EucalyptusRotation**' to the top (parent) Simulations level, which should provide an identical but renamed simulation. Rename it to '**EucalyptusRotationDry**'.
	m.	Copy the ClimateController tool from *Management toolbox*/Weather, and paste it into the individual simulation at the same level as the weather node or Weather node. Change rainfall multiplier to 0.5.
	n.	Run all simulations by choosing the run option while at the top Simulation level. It is also possible to run only the newly created or changed simulation, but then you would also have to refresh the Datastore after running to display updated results at the top graph level.
	o.	DataStore and Reports: Results of simulation runs are shown in the DataStore and Reports (Data tab). View them to know the locations of your data. Reports automatically become part of the Datastore, and

	any graphs are produced from these data. Right-click on the Datastore to export in Excel format. p. Within the graph options for the series, choose 'Colour by Simulation name' and click on 'Show in legend' q. This should show you both simulations plotted on one graph.
10. Download a soil	a. **CREATE A NEW SIMULATION:** Copy, paste (or drag) the **EucalyptusRotation1** simulation to the top Simulation level and rename it 'LincolnDry', which should provide an identical but renamed simulation. Save. b. Right-click on the plantation node c. Select Download Soil d. Click on Search for soils e. Choose 'Loam (Lincoln No 1404)' f. This soil won't work yet, as it doesn't have the 'EucalyptusSoil' plant type at the Physical node g. Delete the previous soil in this simulation, as you only want one soil in each Plantation (stand) h. Copy and paste WheatSoil into the same Physical node. Rename it EucalyptusSoil. By this we are saying that a eucalyptus root behaves like a wheat root. At the 'Water' node, which sets the initial soil water content, change Percent full to 60. i. You just added a soil from a soil database for a location within 10 km of the weather file location. j. View the graphs to see the difference it made.
11. Download met	a. **CREATE A NEW SIMULATION:** Copy, paste (or drag) the **LincolnSoilDry** simulation to the top Simulations level, which should provide an identical but renamed simulation. Rename it '**WarragulMetLincolnSoilDry**'Right-click on the simulation node b. Select Download Weather c. Provide latitude and longitude OR place name (e.g. Warragul) and Get location for placename (which will update the latitude and longitude to the Warragul location), complete other requested information including Data Source, and Ok d. Click on Save. Run all simulations again (or just the new one and refresh the Datastore) and check graph. e. Add these lines to your Report (Fw is a water stress index for leaves, Fn is nitrogen stress index for leaves, 0 = total stress, 1 = no stress): [Eucalyptus].Leaf.Fw [Eucalyptus].Leaf.Fn f. Run, then create a graph each of water (Fw) and N (Fn) stresses in relation to date (Clock.Today) g. Change rainfall multiplier to 2, then back to 0.5 and observe the effect on tree growth and stresses. h. Did productivity change in a reasonable way? There is already a lot of N and some water stress in the simulation; more rain (via rainfall multiplier = 2.0) is leading to more N leaching, more N stress and less growth.

12. Modify soil and met	a.	**CONTINUE WITH PREVIOUS SIMULATION:** For practice, change some soil values within a reasonable range, e.g. rooting depth (XF = vertical growth rate restriction factor 0-1), LL, and C:N ratio. Rerun the simulation and check the effect on tree growth.
	b.	Note that we have been working with minimal met files. Other columns can be added, e.g. wind and CO_2, but that is most easily prepared in Excel. A CO_2 column is already provided in an alternative met file 'WarragulCO2.met'. If CO_2 data are provided, APSIM takes them into account. Copy and rename the most recent simulation to '**WarragulMetLincolnSoilDryCO2**', and use this modified met file. What effect did that have on predicted growth? Answer: Because CO_2 concentrations are higher than previously assumed, it results in increased DBH over the period of the first rotation in our simulation (c. 3% increase).
13. Replacements and Map	a.	**CONTINUE WITH PREVIOUS SIMULATION:** At the top Simulations level, right-click to Add model. Select Core/Replacements.
	b.	From any of the individual simulations, copy the Report and paste it into the Replacements node. This will enable us to change a report here, which replaces it for all reports of exactly the same name in all individual simulations.
	c.	~~From any of the individual simulations, copy the Report and paste it into the Replacements node~~. Add a Map to the top level of the set of simulation.
14. Modify a report or create a new one	a.	**CONTINUE WITH PREVIOUS SIMULATION:** Lines of a report can be commented out with //
	b.	Tips for preparing reports are available near the bottom of the page at: https://apsimnextgeneration.netlify.app/modeldocumentation/ in the Report Tutorial.
	c.	For practice, and as an alternative to how we previously added Fn and Fw to the Reports, in the Report in Replacements, in Reporting variables, type at the bottom below existing variables reported [Eucalyptus]., with the dot.
	d.	You should see some options pop up. Select Leaf. There are many variables to choose from to report. Type another dot for another level of options and select Fn.
	e.	Do the same, but select Fw.
	f.	This adds the two main stresses of interest: Fn nitrogen stress, Fw water stress. This practice has double reported Fn and Fw. So comment out one each of the with //, or delete one line of each.
	g.	Reporting so far has been daily, but we'll now change that to annual.
	h.	Copy, paste and rename the Report in Replacements as 'ReportAnnual'
	i.	Change its reporting frequency to [Clock].EndOfYear and delete the less interesting variables, e.g. [Eucalyptus].Branch.Wt.
	j.	Copy ReportAnnual to all the Plantation node of simulations
	k.	Rerun that simulation and view the data in the new report.
15. Build an experiment	a.	**CREATE A NEW SIMULATION:** Experiments in APSIM, which works like Replacements, can be very useful for efficiently building multiple simulations that have a similar base. This could be, for example, to emulate a real experiment in the field or glasshouse, or to investigate sensitivity to one or a combination of variables in a simulation.

b. Open the Factorial example simulation, and copy the **PropertyReplacement** experiment across to your simulation stack. The factors in an experiment will replace the values of the nominated node in the base simulation, similar to what we just did for reports in the Replacement node.
c. Replace the base simulation in that with the latest you developed above, i.e. WarragulMetLincolnSoilDryCO2.
d. Copy the 'Fertilise on fixed dates' tool from the *Management toolbox* into your simulation at the Plantation node and change its name to 'FertiliserRule'.
e. At Factors/Fertiliser, change 'ApplicationAmount' to 'Amount'. Delete the current 25 and 75 Factor options that came over from the Factorial example to provide: [FertiliserRule].Script.Amount = 0, 50, 100.
f. Rename that Experiment node and base simulation to e.g. '**WarragulMetLincolnSoilDryCO2NExpt**', and delete it's graphs as they will not display anyway at this level of an experiment. Delete the Memos.
g. Add [Nutrient].MineralN to the Report and ReportAnnual in Replacements, which will report the amount of mineral N (NH4 and NO3) in each soil depth.
h. Run the simulation and look at the 'Soil N level ' graph after choosing the y-axis to be Nutrient.MineralN(1), which is the amount of mineral-N (kg/ha) in the top depth of soil. Other depths or related variables could also be chosen for plotting. By looking at the graph, note that the amount of nitrate-N increased each April by the amount applied for each level of the FertiliserRule specified.
i. Note at Factors/Fertiliser node that we have four options for specifying factors (treatments) in the experiment. We will practice the first 3 options, and have just done *Option 1*. Option 4 has an example in the 'CompositeFactor' experiment of the Factorial example. Try option 4, if you wish.
j. If treatment combinations in an experiment are set up correctly, the combinations of treatments to be simulated will be visible at the top of the Experiment node called 'WarragulMetLincolnSoilDryCO2NExpt'.
k. Run the experiment simulation and check results.
l. *Option 2.* Change '0, 50, 100' to '0 to 200 step 50'
m. Run the experiment simulation and check results.
n. It is difficult to understand the DBH graph, for example, as there it now contains too many lines. So copy that graph and place it at the Expt node, which will restrict it to only showing results from our experiment. Alternatively, disable all other simulations, or toggle the simulation names in the graph legend.
o. *Options 3*. Where in option 1 you had typed '[FertiliserRule].Script.Amount = ...', delete everything after ']'.
p. Copy the 'FertiliserRule' node from the base simulation 3 times into the Fertiliser node of the experiment. Therein, change the rates to 0, 50 and 200, respectively, and rename each one to 0, 50 or 200.
q. Run the experiment simulation and check results.
r. The name of this experiment is quite long. Change it to ManagerExpt. If you want to try something a little more complex. I suggest you add stocking as a factor by adjusting within-row spacing, and using the 'Permutation' node from 'Permutation' experiment in the Factorial

	example. For example, as a level of a Stocking factor, add TreeManagement twice and change within-row spacing to 4.1667 to achieve 800 tree/ha and to 2.083 to achieve 1600 trees/ha. Don't forget to specify [TreeManagement] on the righthand side of the screen to tell the experiment structure to expect that type of node to be added under that factor level.
16. Add uniform or biased mortality and thinning as an Operation	a. **CONTINUE WITH PREVIOUS SIMULATION:** At this stage of APSIM development for plantations, users specify exactly the population density (stocking) – from planting to the end of the simulation, as mortality is not currently induced in the model by density dependency, environmental stress, or age. This is an area for future model improvement. b. Open the Pinus example. Find and copy from the Pinus example into the most recent of your simulations (at the Plantation node) the nodes called 'TreeThinning', 'TreeThinningFromAboveOrBelow' and 'Management' (not 'TreeManagement' which is already in your simulation). c. In 'Management' type: 1998-12-31 [TreeThinning].Script.DoThin(0.5); 2000-12-31 [TreeThinningFromAboveOrBelow].Script.DoThin(0.5), or similar text can be copied from the factor level in the Pinus experiment. d. The 'TreeThinning' script achieves a uniform thinning, e.g. every third row or mortality that is uniform across all tree sizes. In contrast 'TreeThinningFromAboveOrBelow' achieves a biased thinning or mortality to reflect thinning from above or below, i.e. proportionally more or less biomass is removed than the number of stems. Look in the script to find ThinBias = 0.7, which is where this thinning bias can currently be changed. A value 0 to 1 produces a thinning from below (preferentially removing the smaller trees); 1 is a uniform thinning; a value 1 to 2 produces a thinning from above (preferentially removing the larger trees). Change the value to 0.3. Run the experiment again and look at the DBH graph. Also add a graph of aboveground biomass. In both these cases, 50% of the number of trees have been removed, but the two thinning options have different effects on DBH and biomass. If the graphs look too complicated, reduce the number of factors or levels of a factor in the experiment by disabling them or deleting them. e. The 'Management' node here is a renamed Operation node, which enables a model on a specified date to be called and told to do something by providing the inputs for that model. Here we used it for thinning, but any model in a simulation can be called, e.g. fertilization. f. Tip: Adding a graph at different levels of the simulation will result in different levels of data that can be sourced for a graph – the higher the level the more data are available. Keeping a graph at a low level reduces clutter and complexity of graphing if you have more than one simulation or experiment, but the opposite is useful if you want to view all those in one graph.

	g.	By disabling and then enabling Management, and rerunning and viewing results in between, you can notice the effect of mortality and thinning on the results. Rather than iteratively toggling Enable like this, Management could have been added as a factor.
17. Add fertiliser and weeds	a.	**CONTINUE WITH PREVIOUS SIMULATION:** Let's look at the Management toolbox in more detail: Various forms of N fertilizer can be added to a zone by using the fertilizer tools from the *Management toolbox*. Crop sowing and tree management tools also include options for fertilizing at sowing or planting. Fertilizer can also be applied as an Operation – copy the specific syntax required from another Operation, and modify the date, and fertilizer amount, type and depth.
	b.	Information: More than one plant can be grown in a zone (plantation) of a simulation, e.g. pasture or an annual crop can be sown, managed, harvested or grazed. This provides one method of including weeds in plantation simulation, and such weeds can usually be forced to approximate expected weed behaviour in terms of light, water, N use. Apart from pastures or crop species already available in APSIM, SCRUM is a functional plant model that provides a simplified plant for the purpose of using resources in that zone. Caution: This weed options have not been fully evaluated for plantation forestry.
	c.	Information only: A 2-zone system is also available as the 'Gliricidia Stripcrop Example' in the Agroforestry folder of examples. Theoretically, Gliricidia can be substituted with Pinus or Eucalyptus as the tree species, and another plant species added to the 'crop' zone. Caution: This option has not been fully evaluated for plantation forestry.
	d.	Include a weed (barley) in a simulation: Copy and rename your previous simulation . As an example of b above, sow a crop of barley every year (but don't harvest it) by copying nodes 'Barley' and 'Sow on a fixed date' from the Barley example into your Plantation node. Also add a BarleySoil to Soil/Physical by copying and renaming the EucalyptusSoil node. Don't copy the BarleySoil from the Barley example, because it will have different soil depths and won't be compatible with the soil that we are using.
	e.	Add a report line [Barley].AboveGround.Wt, disable all other simulations, as they don't have barley.
	f.	Run the simulation.
	g.	Add barley AboveGround.Wt to the AboveGroundWt graph that you already have, by duplicating the graph series, renaming them Trees and Weeds, and for Weeds, choose Barley aboveground wt to plot, and use a right axis and dotted line.
	h.	The graph should show that barley grows during the first few years but thereafter appears to be outcompeted by the trees.
18. Include observed data	a.	**CONTINUE WITH PREVIOUS SIMULATION:** If available, observed data can be include for comparison to predicted values. This can assist in evaluating the level of confidence to be placed in predictions. Comparisons of temporal trends are also possible. Model skill can also be formally evaluated using statistics that are calculated in APSIM.
	b.	Data are imported into APSIM as a node under the Datastore. The node can be found at Add model/PostSimulationTools/ExcelInput.

	c. We need to provide a .xlsx file of observations. Use the one provided called 'ObservedDataForPlantationForestryTraining.xlsx', which contains entirely hypothetical height data. The top row provides column names, the first of which is essential and must be named 'SimulationName'. Various columns provide the x or y values of graphs that you plan to plot. Provided in the example are Clock.Today and Eucalyptus.Stem.Ht, which must exactly match those reported for predictions. d. At the observed node in the Datastore, direct it to the location of the observed file, and specify the name of the worksheet 'Height'. e. Refresh the Datastore and check that it has imported the observed data by viewing them in the 'Height' report. f. Copy the previous experiment, rename it and the base simulation 'ExptWithOvP'. Modify and simplify it to be only an N rate experiment with at least the N fertiliser rates of 0 and 150 kg N ha^{-1}, i.e. delete other levels of the NRate factor, and other factors. g. Extend the harvest age to 12 years h. Run the simulation. i. Refresh the Datastore j. Add a graph of tree heights. Duplicate the Predicted node and rename it Observed, and change its report (data source) to Height. k. For the Observed node, use markers instead of lines.
19. Include OvP node and graph	a. **CONTINUE WITH PREVIOUS SIMULATION:** Add to the Datastore Add model/PostSimulationTools/PredictedObserved. Rename it OvP. b. Complete the requested information for reports to be used to construct an OvP report, with predicted values to come from the Report, observed values to come from Height, and SimulationID for first field name for matching, and Clock.Today for second field name for matching. Leave the third field name for matching blank. c. Refresh Datastore d. Copy and paste one of your x-y scatter graphs and rename it OvP Height e. Refine it: Use Data Source as OvP, x-axis as Predicted.Eucalyptus.Stem.Ht, y-axis as Observed.Eucalyptus.Stem.Ht f. Add to the Series level: Add model/PostSimulationTools/Regression. g. You should see an x-y plot of observed and predicted heights and statistics in the top left corner. h. The appearance of the graph probably needs changing, e.g. no lines, and markers and colours by SimulationName, and legend place at bottom right. i. Predicted heights are only reported if > 3 m. It therefore does not make sense to include comparisons below this height. So, filter this graph with '[Observed.Eucalyptus.Stem.Ht]>3.0'
20. Calibrate soil and use a graph filter	a. **CONTINUE WITH PREVIOUS SIMULATION:** OvP graphs are rarely initially as good as you want them to be. Improvement might be provided by calibrating input values of soil, genotype or climate, if that is justified. Unmodified soils are usually under suspicion for not being completely correct. Here we work through a simple example of calibrating a soil. Plant parameters in the cultivar file might also need calibration for the

	production of a new cultivar, but that can be more complicated and it is not recommended until you have fully develop advanced skills in APSIM. Minor climate changes can be handled using the climate controller. b. The OvP graph above indicated that we over- or under-predicted observed height. Perhaps water or N was more or less available in this simulation than in reality. c. First check on the extent of N and water stress (Fn and Fw, respectively) by copying those graphs from the previous experiment into this one. You should see that we have N and water stress in the system for most treatments. But we are actually over- or under-predicting, which means we need more or less stress, respectively. So we need to decrease N and water uptake to achieve better OvP statistics. d. Iteratively change Soil.Physical.Eucalyptus LL and Eucalyptus KL for various depths, and also Soil.Organic.C and CNRatio, and check the resultant OvP fit – trying to achieve 1:1 agreement. There are many combinations of these parameters that would achieve a suitable result, and one way to check that we are changing the right parameters at the right depth would be to also have OvP graphs for soil water and soil N availability, but we don't have those available to us for this example. e. Change EucalyptusLL (plant lower limit of water extraction, mm/mm), EucalyptusKL (plant daily maximum proportion of available water that can be taken up, mm/mm), EucalyptusXF (plant vertical root growth factor; 0 = no root growth), Initial water (mm), and Soil.Organic C (%), C:N, FBiom (fraction of C and N in microbial biomass), and FInert (fraction of C and N inert; 1 = none active). A combination that works is shown in the screenshots. f. If you need a more detailed explanation of soil parameters, refer to (1) https://www.apsim.info/wp-content/uploads/2019/10/Soil-matters.pdf, (2) https://www.apsim.info/wp-content/uploads/2021/01/Methods-for-PAWWRC-estimation_DNRME.pdf, (3) https://www.apsim.info/wp-content/uploads/2019/09/Parameters-for-soil-water-Ver20-190815.docx g. Any of the other soil parameters, e.g. in SoilWater, Chemical and Water, might also have been justifiably changed. h. Note the improvement in model skill
21. Build your own case study and extending your skills	a. You now have the basic skills needed to design and build you own simulation using the above elements. Start simple then build complexity. b. There are many additional options and capabilities in APSIM that you have not been introduced to yet, but which you'll discover as your experience grows. Tips to expanding your capabilities is to view the video training exercises, examples and tutorials, read recent papers about APSIM use, and by sharing APSIM experiences with collaborators. c. Another level of complexity is to join the APSIM community on GitHub, download and run validations, and track the linked code of models if you want to understand more of the detailed coding behind APSIM and become a developer. d. But you don't need to be working at that level to submit issues for problems that you are experiencing, or suggestions for improvement.

	e. Developers from several countries are continuously and simultaneously working on many different aspects of APSIM, and there is a small team that checks almost daily for issues solved and the need for a new version to be released.