What is the Little Fireface Project?

The Little Fireface Project (LFP) studies the ecology of the slow and slender lorises, and contributes wherever possible to the conservation and ecology of loris species thought their range. This encompasses conservation of their habitat and wider ecosystem. The LFP therefor conducts evaluated outreach and education programs for local communities to get them to join the conservation movement. Their main current field project is on the Indonesian island of Java, where they conduct country wide conservation programs on animals such as colugos, pangolins, civets, small cats, mustelids and owls.

About this pack

Ecosystems worldwide have undergone severe losses in biodiversity and ecosystem functioning. To foster resilience and ensure the long-term stability of biodiversity, the regeneration of plants is critical. Plant regeneration comprises a cycle of life stages from seeds to seedlings to reproducing adult plants. Processes that facilitate this transition include pollination and seed dispersal.

This resource has been produced to help teachers and other educators introduce students to the ecosystem services that Java's biodiversity provides, and encourage compassion towards pollinators, seed dispersers and their ecosystems. It begins with introductions to pollination, pollinators and seed dispersal and develops to explore why they are important to humans, and how humans are disturbing their ability to function properly.

This resource provides teachers with tools and activities to deliver an engaging education program that inspires learning, reflection and action among children and their communities relating to why healthy animal populations and their ecosystems are so important.

Intended audience:

This resource is intended for teachers of students aged between 7-12 participating in conservation education. It can be used across a wide range of academic situations (schools, nature schools, scouts and other children's programs).

What is in the pack?

This pack contains useful information about primates, birds, bats, and insect's essential roles in pollination and seed dispersal. The structure of the lessons involves the following three steps:

Learn: Students explore the content by teacher led lectures, with the use of extra learning resources.

Act: Students complete tasks that consolidate learning in their own lives, homes and communities and result in positive outcomes for biodiversity. A variety of activities are provided in order to accommodate a variety of learning contexts; it is the educator's responsibility to choose the most suitable to their educational setting.

Reflect: Students should try to answer the reflection questions. They encourage students to actively reflect on the information learned in the lesson plan and activities. The information gained from this section can help the teachers gain insight into the students understanding of the lesson. Once students have attempted the reflection questions, a class discussion regarding the content should be led by the teacher.

Content and accompanying resources required:

Chapter 1: Introduction to pollination
Class resource required: Flower anatomy hand-out
Pollination activity's: Pollination hand-out
'Cut and Stick' activity: Flower anatomy cut and stick hand-out

Chapter two: Introduction to pollinators
Class resource required: Pollinator anatomy hand-out
Observing pollinators activity: observing pollinators hand-out

Chapter three: Pollinator and flower relationships
Pollinator-plant activity: Pollinator-plant observation hand-out
Memory: Pollinator-plant memory cards

Chapter four: Pollinations importance in our world
Class resource required: Pollinated strawberry hand-out
Cooking with Pollinators activity: pollinated and un-pollinated foods (or images)
Farm Visit activity: Accessibility to a farm
Memory activity: Flower-vegetable memory cards
Memory activity: Match the items hand-out

Chapter five: The importance of seed dispersal
Most Likely Too activity: a diversity of seeds that use different modes of dispersal

Lost or Found activity: a large seed e.g. acorn
Relay activity: Straws and dandelion

Chapter six: What is happening to pollinators and dispersers
Grow your own activity: grow your own plant kit (seed, compost, water)
Make your own fertilizer activity: Fertilizer recipes hand-out

Chapter seven: How will their loss affect us?
Class resource required: Ecosystem handover
What do you need to survive activity: Biologist cue cards

Chapter 8: How can we protect them?
Activity resources: coloring pencils, pens, paints and paper

Vocabulary

Biodiversity: the variety of plant and animal life in the world or a particular habitat.
Ecosystem: a biological community of interacting organisms and their physical environment.
Sustainable: conserving an ecological balance by avoiding depletion of natural resources.
Organisms: an individual animal, plant or single-celled life form.
Pollination: a necessary step in the reproduction of flowering plants; the process by which pollen is transferred from the male stamen to the female stigma, thereby enabling fertilization and sexual reproduction.
Pollinator: an email that involuntarily transfers a flowers pollen from male reproductive organs to female reproductive organs.
Stigma: the pollen-receiving tip of a flowers pistil (female part)
Stamen; the pollen-producing reproductive organ on a flower (male part).
Nectar: a sweet liquid secreted by flowers as an attractant and reward for pollinators
Pollen: a powder-like substance in a flower that is made up of grains. Each grain functions as a capsule for carrying male gametes (sperm cells) of the plant.
Adaption: a living organisms physical/behavioral features that aid it in surviving within a specific habitat.

Chapter one: Introduction to pollination

Aims:

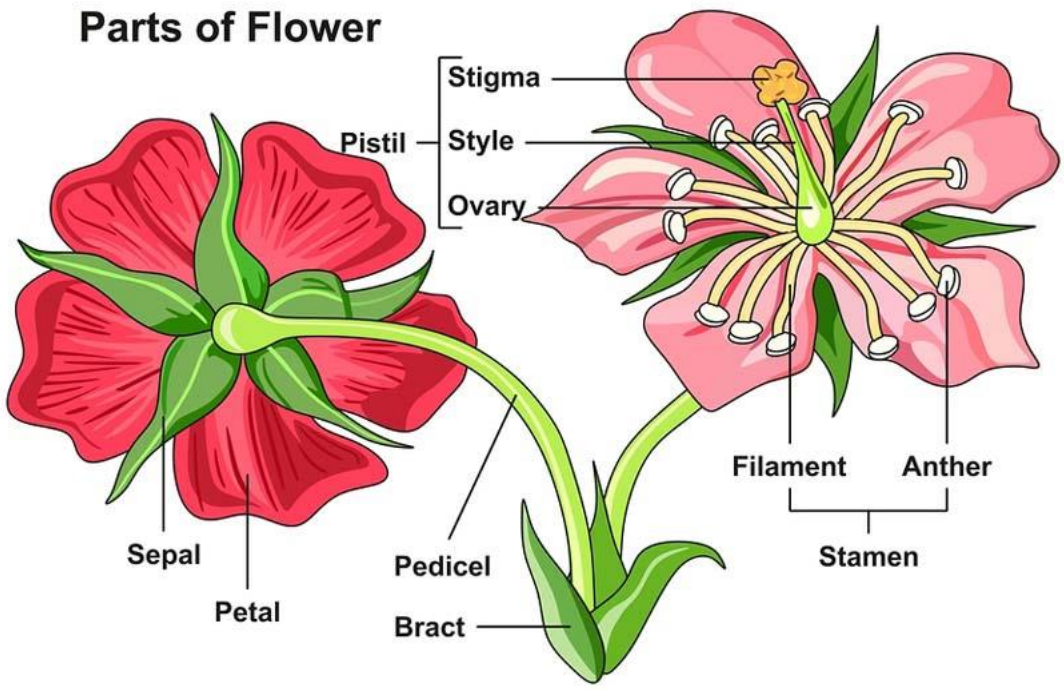
1. **Students will learn what pollination is and how it occurs.**
2. **Students will learn the anatomy of a flower.**

Learn:

Pollination is a very important part of the plant life cycle. Many plants need pollination in order to reproduce. Pollination is the process of transferring pollen from the male part of the plant (the anther) to the female part of the plant (the stigma) to fertilize the plant and make new plants (seedlings).

Flowers have many different colour's, smells, tastes and shapes. These are more than just to look at, they have important roles in attracting birds, bats, insects, and small mammals to help with the pollination process. By attracting an animal to the flower, the animal is rewarded with a sugary substance called nectar or a nutritious protein called pollen. The animal's presence at the flower results in pollen being transferred onto the animal's body. When the animal then goes to a new flower in search of food, the pollen from the previous flower is usually transferred to the stigma of the new flower, which travels to fertilize the plant. A seed is then formed and eventually drops to the ground. Water, wind or animals then help the seed to move to a new area where it will grow into a new flower. Without pollination, most plants would not be able to reproduce and produce seeds.

Class activity: go through the flower anatomy with the class using the flower anatomy handout.



The centre of a flower contains its sex organs, which may be male (stamen), female (pistil) or both. The stamen consists of an anther, which produces pollen, and a filament, which connects the anther to the rest of the flower. The pistil is the seed-bearing part of the flower and contains the stigma, which collects pollen, and a style, which connects the stigma to the sex organ, or ovary.

Surrounding the flower are petals, which both protect the flower and attract pollinators. Sepals are green flaps that protect the flower buds and fall to the ground once the flower opens. The stem is the part of the flower that supports buds, leaves and flowers. The leaves produce food for the flower. They collect sunlight to make food and their leaf veins are responsible for transporting both food and water throughout the flower.

Act:

1. Using nature: if you are close to a green space, in groups of 5+, should each pick a flower of their choice. One per group. Ask them to come inside to disect and label it. Discuss the stem, the leaves, the stamen, where the organs are located and so on. Explain how each part serves its purpose (e.g. the stamen is the male organ responsible for producing pollen). They could glue it on a piece of paper and label the different parts with a shor scentence explaining what the part is responsible for. The groups showuld then present their flower to the class. This activity will show that regardless of shape, size or colour- all flowers have the same basic parts in order to perform the task of repoduction.

2. Flower arts and crafts: provide your students with coffe filters and have them put their name on the back in biro. Let them colour them in with washable markers and mist them with a spray bottle after. Repeat the same process using cupcake liners. As these are drying, give the students pipe cleaners (prefrable orange or yellow) for the flowers stamen. Bend them into L shapes. Once the filters are dry, the students should contruct the flower. Place and glue the muffin liner on the front and center of the coffe filter. Add glue to the small end of the L shape pipe clearner and stick this onto the muffin cup so that the longest part faces out. Glue the flower to a sheet of paper and let the students label their flowers. [Arts and crafts flowers could be made from any resources available, this is only one example]. This activity will familiarise students with flower anatomy.

3. Understanding pollination: using pipe cleaner, bend it into an insect shape (a bow). Poke a hole in the bottom of a plastic cup and insert another pipe cleaner so that if forms a flower pistil. Tape the pipe cleaner in place on the bottom of the cup. Wrap tape sticky side out on the end of the pipe cleaner. Sprinkle chalk powder in the bottom of the cup, making sure not to get any on the sticky pipe cleaner. Students should fly their insects in and out of oneanothers cups- allowing them to touch the taped pipe cleaner. As a class, discuss what happened to the taped pipe cleaner? Are there different colours on it? Discuss what happened to the “pollen” and how it relates to real flowers. They can document this process using the pollination handout. This activity will familiarise students with the pollination process.

4. Pollination by Cheetos: each students should be provided with a brown paper bag with a flower drawn onto it. They can draw their own flower if they like, but make sure that it is big. Put a handful of cheetos in each students bag. Explain to your students that their fingers are insect legs. Students should pull some Cheeots out of each classmates bag. They can eat the Cheetos, however they must not lick their finders. Students should move from bag to bag collecting dust. Once they have eaten out of everyones bag, they choose a friend and wipe their fingers on a friends flower. It is important to explain that by landing on the flower and transferring Cheeto dust, they are pollinating the flower. They can document this process using the 'pollination hand-out'. This activity will familiarise the students with the polliantion process.

5. 'Cut and Stick' flower anatomy: use the cut and stick activity to familiarise students with flower anatomy and the pollination process. Students should also colour in the diagram. This activity will familiarise students with both the pollination process and flower anatomy.

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. Draw a flower and lable the parts that are most important for pollination

2. Imagine that your friend does not know what pollination is. How would you explain it to them? You can either write it, present it or draw it.

3. Draw what you believe the forest would look like if pollination did not occur.

Chapter two: Introduction to pollinatiors

Aims:

1. **Students will learn about pollinators and their adaptions.**

Learn:

As we have learned in the pervious chapter, flowers come in all shapes and sizes. The animals that pollinate them are therefore likely to have physical adaptions that suit the shape of the flower, so that they are able to reach the rewarding nectar. Animal's also have physical adaptions that make them better agents for collecting pollen, such as fur and feathers where pollen can safely remain for a long enough distance to be dispersed to a new flower. These adaptions are vital for pollination as they ensure both the service and reward. Below are some examples of pollinators and their adaptions for the service:

Bee's are completely dependent on flowering plants for food. They suck up nectar using their specially adapted proboscis and store it in their honey stomach. They have specialised hairs all over their body that attracts pollen grains though electrostatic forces. The stiff hairs on their legs keep the pollen on their body. Their small size allows them to crawl deep inside the flower, covering themselves in pollen.

Butteries do not come close to the flowers pollen like that of a bee due to their large wings inability to fit inside. They therefore do not have such extensive adaptions. Instead, their long thin legs are used to perch on the flower petals, and small amounts of pollen are collected on their legs for transfer while they use their extremely long proboscis to reach the rewarding nectar.

Flies are particularly important pollinators in places where bees are less active, such as in alpine or arctic habitats. Pollen becomes attached to the hairs on their body as they enter or leave the flower. They use their proboscis and long tongue to access the nectar. Like bees, their small size allows them to crawl deep inside the flower allowing extensive pollen collection.

Midges are extremely small, allowing them to crawl into the smallest of flowers and collect pollen on their body. They are one of the dominant pollinators of the tiny white flowers of the cacao tree, enabling the tree to produce fruit. They are no bigger than pinheads, which makes them able to pollinate the most intricate flowers.

Birds use their long beak to access nectar. Having a long beak to access nectar means that they can keep their body at a safe distance from the flower, so as to not become tangled within it. Pollen is dusted on to their faces as they insert their beak into the flower. Their feathery faces provide grip for the pollen to become securely placed until it is transferred.

Bats are nocturnal pollinators. It is thought that they are responsible for the pollination of over 500 different species of tropical plant, including mango, banana, cocoa, guava and agave. During pollination, the bats face will become covered in pollen as they use their long

tongue to access the rewarding nectar. The hairs on their face and body act as a net to trap the pollen until transferal.

Primates of a large size tend to hinder pollination by consuming the entire flower, however smaller primates (less than 1kg) are able to use their dexterous hands to stabilise the flower and use their tongue to lick the nectar from the flower, such as the Javan slow loris. During this process, pollen is transferred to the face, hands and general fur until later deposited.

Rodents prefer those plants that keep their nectar deep inside a sturdy outer shell rely on the small mammals for pollination as they possess sturdy teeth to break though the case. These plants usually have bright pollen covered anthers on the exterior of the case, meaning that when rodents begin biting though it in order to access the rewarding nectar, their face become doused in pollen.

In class activity: use the pollinator pack cards to introduce students to Javas different pollinators

Act:

1. Observing pollinators: take your students to an area where there are plenty of flowers growing. In order to see a variety of pollinators, the day should be fairly warm and dry. Approach the area quietly so as to not frighten everything off. Remember, don't touch! Look and listen. Use the 'observing pollinators' hand out to document what was observed. Discuss what pollinators were observed, and how they were approaching/interacting with the flowers. This activity will help students learn about the different types of pollinators that can be found in a garden.

2. Pollen collector: using what resources you have available, in groups students should experiment with a variety of materials/textures which is best at picking up crushed chalk (pollen). Materials such as feathers, pipe cleaner, hair, and sponge can be used to reflect animal adaptions. Students should rate the best to worst pollen collectors, and explain the reasons for why they selected the best and worst collector. This activity will help students to think about how pollinator adaptions help them carry out their important job. This activity may inspire student's ideas for activity 3.

3. Design a super pollinator: consider the animal adaptions that the students have just learnt about. Ask them to design a super pollinator based on this. Students should name their super pollinator and explain to the class why it would make a good pollinator. They should explain what they eat, where they live, what they like to do and why they help the garden. They should be encouraged to take it home and introduce it to their family. This activity will encourage students to think about how pollinator adaptions help them carry out their important job.

4. Drinking, licking, biting: ask your students to think about the different ways in which animals eat. Some drink, some lick and some chew. Many pollinators use either a long tongue or a proboscis to drink or lick nectar. This activity explores why this is beneficial for nectar, but not other foods. Using a shortened straw to reflect a proboscis, students should try to consume a) peanut butter, b) crackers, c) honey or jelly, d) juice or water from a cup. Students should try the same using only their tongue. Lastly, students can try to consume the foods using their teeth. Explain to the class how nectar is a sugary liquid that is similar to foods c and d. Where they the easiest foods to consume using pollinator adaptions? As a class you should consider why it is beneficial for pollinators to have these adaptions. This activity will encourage students to think about the importance of adaptions.

Reflection:

Answer the following questions individually, and then as a class discuss them.

1. Name two nocturnal pollinators. One that has wings, and one that does not have wings.

2. Why are pollinator adaptions so important?

3. Draw or name and adaption which you believe is the most beneficial for pollination.

Chapter three: Pollinator and flower relationships

Aims:

1. **Students will learn about flower adaptions for attracting pollinators**
2. **Students will learn that some flowers attract a certain type of pollinator**

Learn:

Over millions of years, flowers have developed scents, colour's, markings and shapes to attract pollinators. If you look closely, you can see that there are certain flowers that certain pollinators like.

Bees prefer sweet and bright yellow or blue flowers.

Butterflies are often attracted to yellow, orange, and pink as well as fragrant ones. They also prefer flowers with large flat petals for which they can sit on while drinking nectar.

Flies prefer pale or dull browns and purple flowers that have a bad odour that reflects rotting meat, dung, sap and blood. This is an impressive flower adaption, as it has evolved a colour and sent that imitates fly's main food source, ensuring that they are able to get pollinated.

Birds prefer bright red, orange and yellow flowers. The flowers are usually sturdy and orientated in a way to allow the birds to stay near the flower with out getting their wings entangled. They therefor are usually curved or tubular in shape, allowing their long beaks to easily fit inside them to gather nectar. They do not seem to be attracted to fragrant flowers, likely because they have poor sense of smell and good sight. There must be sufficient nectar present in order to reward the bird for the time spent at the flower.

Bats tend to prefer white or pale nocturnal flowers so that they can be distinguished from their dark surroundings at night. They are naturally large and wide mouthed so accommodate the head of the bat. The flowers are particularly fruity or musky smelling, making them attractive to nocturnal bats due to a reliance on smell over sight. They must have a large amount of nectar in order to be enough of a reward to the bat for pollination. The same can be said for moths.

Rodents are often attracted to plants based on their scent. It is the strong musty or yeast sent that attracts them.

Slow loris is a nocturnal and small pollinating primate that is attracted to the bright pink and fragrant Kaliandra flower.

Did you know: it is likely that some flowers have evolved to attract certain animals due to their services beyond pollination, e.g. about 40% of hoverflies bear larvae that prey on other insects, which thereby provide pest control services to the plant being pollinated. They pollinate a variety of fruit crops, such as apples, pears, cherries, plums, apricots, peaches, and various berries. Recognise that the colour of these fruits are similar to that of flies main food sources. In addition, bats are well known for keeping insects and bugs away from crops. They consume June beetles, stink bugs and corn worm moths which are known to destroy crops. Because bats and birds are migratory, they carry pollen great distances, introducing new plants to various locations helping regenerate worn areas.

Act:

1. Design a super flower: your students should design what they believe a super flower might look like. They should name it, and explain where it lives. Students should consider what pollinator or pollinators they want to attract and what adaptions are required to do so. This activity will encourage students to consider the different adaptions flowers use to attract pollinators.

2. Pollinator-plant observations: take your students to an area where there are plenty of flowers growing. In order to see a variety of pollinators, the day should be fairly warm and dry. Approach the area quietly so as not to frighten everything off. Remember, don't touch! Look and listen. Use the 'pollinator-plant observation' hand out to document what pollinators were observed near which flowers. Document the pollinator and the colour, shape, scent and location of the flower. In class, discuss if the class results are similar to that of what has been discussed in the lesson. This activity will exemplify the specific pollinator-plant relationships.

3. Design a pollinator friendly garden: students should consider what types of pollinators they want in their garden? How they will attract these pollinators? How the pollinator will access the garden? What does a pollinator need to inhabit an area (shelter, food, water) and how will they be provided? They should be encouraged to present their garden ideas to the class in order to exemplify their thought process and inspire one another. This activity will encourage students to consider the different pollinator-plant relationships as well as what pollinators need to survive.

4. Memory: students can play memory using the plant-pollinator memory cards provided. They should match the flower with the pollinator. E.g. large petal and butterfly or small white flower with midge. It may be necessary to have a teacher present to help students realize the correct pair. This activity will encourage understanding of the pollinator-plant relationships as well as improve cognitive thinking.

5. Talent show: line up a variety of flowers. There should be different smells and appearances. Students should judge the flowers using the 'talent show' hand-out.

Consider how these flowers talents attract certain pollinators. E.g., very fragrant flowers attract nocturnal pollinators. They should suggest which animal would be attracted to which flower. This activity will encourage understanding of the pollinator-plant relationships.

6. 'A day in the life of': students should choose a pollinator and describe what the average day of that pollinator might be. This could be drawn like a story board or written down as a short essay. They should consider what adaptions the pollinator uses, how it approaches the flower, what flower it will most likely approach, where does the pollinator live, does it need to avoid any predators? This activity will encourage students to consider the life of the pollinator beyond pollination.

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. Can you name one plant-pollinator relationsip (e.g. bees prefer bright yellow or blue flowers).

2. Why do you think that it is important for flowers to be attractive to animals?

3. Draw a picture of what you think a field would look like if the only pollinators in the area were flies.

Chapter four: Pollinations importance in our world

Aims:

1. **Students will learn that many resources they take for granted require pollination**

Learn:

We now understand that pollination is essential for the reproduction of plants. However, it is important that students make the connection between pollination and the plants that features heavily in our day-to-day living. Pollination occurs in 1) fruits and nuts; 2) vegetables; 3) cereals; 4) drug, beverage, condiment and spice plants; 5) forage crops; 6) timber trees and natural vegetation, and 7) fibre plants and rubber. These are components required to build our homes, feed our families, medicate our families, dress our families, feed our livestock and produce a stable income. By understanding the dominant role that pollination plays in our lives, students may become more compassionate towards our pollinators.

In class activity: hand out an array of items that would not be possible without pollination e.g. coffee, chocolate, cotton, honey, wax, fruit and vegetables allowing students to explore various pollinated products.

Beginning as a flower, pollination activates the process of seed growing and therefore fruit bearing. Pollination therefor plays an enormous role in the wild and agricultural production of essential plants. As much as 75% of the worlds crops producing fruits and seeds for human consumption depend, at least in part, on pollinators for sustained production, yield and quality. The diversity of food available is largely owed to pollinators.

Some examples of food that requires pollination are:

Fruits & Nuts	Vegetables	Others
Apple	Artichoke	Coffee
Apricot	Broccoli	Black pepper
Crab-apple	Celery	Sesame
Cashew	Eggplant	Dill
Fig	Pumpkin	Nutmeg
Pomegranate	Turnip	Parsley
Blackberry	Asparagus	Sunflower
Chesnutt	Chicory	Fennel
Coconut	Leek	Lavender
Oil palm	Watermelon	Vanilla
Date	Cauliflower	Guava
Papaya	Cucumber	Coriander
Strawberry	Green pepper	Tea
Cacao	Beet	
Olive	Carrot	
Peach	Chive	

Pear	Parsnip
Plum	Radish
Macadamia	Tomato

It is recognised that pollination improves the size, shape, vitamin sufficiency and over all food quality, and therefore significantly improves the crops value compared to those un-pollinated crops.

> In class activity: discuss the difference between pollinated and non-pollinated vegetables. Use the 'pollinated strawberry' hand-out or physical fruits if available to help demonstrate the difference in size, shape and vitamin sufficiency.

The presence of pollinators therefor increases the stability of crop production, reducing the year-to-year variability and boosts their economic stability. Without pollinators, we would not have such a large pantry in which to select ingredients for our cooking and medicine.

Pollinators are also responsible for the air that we breathe. Without pollination, trees would not reproduce. Without trees, there would more harmful carbon dioxide and less oxygen in the world. Other than less air in which to breath, with less trees there would less resources for both animals and humans to use for their benefit (e.g. timber, food, shelter).

Act:

1. Cooking with pollinators: display photos or physical fruits, jams, honey, chocolate, vegetables as well as some non pollinated foods (e.g. meat). Ask students to form groups and create a lunch menu using any of these items. Allow them to present it to the class. Then, as a class go though the items and separate them into non pollinated and pollinated foods. It is important to help the students think about whether or not they are flowered at youth. Once complete, ask the students to make another lunch recipe using only the non-pollinated foods. Have a discussion about the significance of pollination to cooking. This activity will help students realise that many foods rely on pollination.

2. Honey: ask students to bring in honey that they have at home. Hold a honey tasting discussion exploring the similarities and differences between them. Explore whether they come from similar or different flowers. A piece of homework can be to interview their parent on what they use honey for around the household and tell the class the next day. This activity will demonstrate the heavy reliance that humans have on honey, which would not exist with out pollinating bees.

3. Cooking at home: as a piece of homework, students should interview their parent, guardian or friend as to what they like most to cook with, why, and how they would feel if that item was no longer available. Students should be prepared to tell the class the next day what they found. In class, separate the foods into pollinated and non pollinated to demonstrate the extent to which family's favourite foods rely on pollination.

4. Farm visit: visit a farm and explore what the different food flowers look like. Students should sketch and label the different flowers in their field guide. Attention should be given to any pollinators that are in action too. This activity will help students realise the relationship between pollination, farms and produce.

5. Memory: use the provided flower- vegetable memory cards. Other class members could do the 'match the items hand-out'. These activities' will help students understand the relationship between pollination and our food.

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. List three of your favourite foods, and label them as either pollinated or non pollinated.

2. Do you think pollinators are important for farmers? If so, why.

3. What do you think would happen if no pollinators were able to reach farmers fields? Draw a picture of what the vegetables might look like on a pollinated and non pollinated farm.

Pollinated vegetable	Non-pollinated vegetable

Chapter five: The importance of seed dispersal

Aims:

1. **Students will learn that seeds need to be dispersed away from the parent plant in order to boost their chance of survival.**
2. **Students will learn that without seed dispersal forests would not survive**.

Learn:

After the flower has been pollinated and fertilised, a seed is formed. It is important that seeds are dispersed away from the parent plant, in order for the seedlings to grow healthily. Getting its seeds dispersed is a difficult task as they are much larger than pollen and need to move away from the parent plant to avoid over crowding and competition for sunlight and water. There are four methods of seed dispersal:

Method	Detail	Examples
Wind	Seeds have lightweight parts, wings, or parachutes	Dandelion
Animals (inside)	Brightly coloured and tasty fruits contain seeds with indigestible coats, so that the seeds pass though the animals digestive systems undamaged	Tomato, plum, raspberry
Animals (outside)	Fruits have hooks that attach them to the fur of passing animals	Goose grass, burdock
Self-propelled	Have a pod that bursts open when ripe, throwing seeds away from the plant	Pea pod
Water	Have tough or waxy outer coating to prevent them from becoming waterlogged, and they are usually buoyant to allow them to travel long distances.	Water lily, coconut

Smaller seeds, some are as small as grains as salt, tend to be dispersed by wind and water. Some large seeds are dispersed by rodents, such as squirrels, that take them and hide them in preparation for hibernation. They are often hidden in the ground, and become lost to the rodent resulting in germination and eventual growth. Other large seeds can be transported long distances by water as their hard cases shelter them from becoming to saturated by water and dying.

Many seeds, however, rely on animals for dispersal away from their parent. Some plants use sticky seeds, meaning that any animals that happen to brush against it is likely to have the seed stuck to it for a short period of time. These seeds use hooks, barbs, spurs and burs to cling on. These seeds can travel many miles before being brushed off, chewed from the fur or released by a burrowing animal. They can even use human clothing as a method of transport.

Seed's that are evolved for dispersal via animal digestion tend to develop fleshy fruit around their seed to attract animals to eat them. The seeds are spit our nearby or can survive the animal's digestive tract. When swallowed seeds are 'deposited' at the other end, they will sprout into seedlings. Plants like apples, raspberries, and many others use this trick to get animals to disperse their seeds.

Did you know: Some seeds, such as blackberries, have hard cases that need to be abraded in an animal's stomach in order to break dormancy and incur growth. Stomach acids and digestive enzymes wear down the hard seed coats, such as cherries, and make them more permeable to water. Therefore, digestion boosts hard seeds chances of germination.

Those seeds that are evolved for digestion tend to be larger seeds, such as species of large tree. It is estimated that 95% of tree species in the tropics produce seeds that are dispersed by frugivorous animals. It is understood that these seed dispersers have significant effects on plant demography and forest regeneration. Because of their high rates of frugivory and relatively large body size, primates have been argued to be a particularly important group in seed dispersal, and therefore tree reproduction.

Did you know: primates, birds, bats, civets, and rhinoceros are dominant seed dispersers.

In class activity: use the disperser pack to introduce students to Javas seed dispersers

Low rates of dispersal are known to cause clusters of plants. The competition between plants in clusters is high and therefore, not all plants succeed into adulthood. Additionally, clustered seeds make seed predation easier for rodents. There are therefore long term consequences of seed dispersal. In the case of trees, without dispersal, less and less trees will be 'born' or reach adult hood, reducing the amount food, shelter and water resources as well as oxygen in the atmosphere, contributing to climate change. Without seed dispersal, the forests will not regenerate after deforestation.

Act:

1. Exploring competition: If you have gardening space available, you should ask a small group of students to plant a seeds in separate areas around the garden, not near many other plants offering minimal competition. The rest of the students

should plant theirs clustered together. Be sure to document on a map the locations and number of seeds planted. As the seedlings grow, students should observe the difference, if there is any, between the clustered and the spacious plant growth. As a class, consider how this may relate to seed dispersal. This activity will demonstrate the importance of seed dispersal and the danger of plant competition.

2. Most likely to: in groups, explore a selection of seeds and decide which is their most likely method of seed dispersal. This activity will demonstrate the different adaptions that seeds have for their primary method of dispersal.

3. Seeds & Socks: on a nature walk, ask students to take of their shoes and walk in their socks (or they can put a sock over their shoe) for a short period of time. Explain that the socks are like animal fur. At the end of the walk, as the students to form pairs and explore what plant matter may have hitchhiked on their socks. They should sketch the seeds in their field book. This activity will demonstrate how easily seeds can be dispersed by animals. A post sock activity: How to plant a seed.

4. Lost or found: give each student a large seed (e.g. acorn) or a grape. Tell the students that they are squirrels and need to hide their seeds. After an hour of activities, tell the students to find the seed that they hid. Did everyone find their seeds? Discuss how squirrels loosing their seeds may help seed dispersal. This activity will demonstrate how rodents can partake in seed dispersal.

5. Seed adventures: Write a story on the adventures of a seed from its birth to its germination. Ensure that there is an equal distribution of different seed dispersal methods across the class. Students should consider the different methods of dispersal and requirements for a healthy growth. This activity will encourage students to think about the process of seed dispersal from start to finish.

6. Relay: Hold a relay race with students blowing into straws and to keep the dandelion seeds airborne. The team that kept theirs airborne for the longest wins. This activity will demonstrate how wind can aid seed dispersal.

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. Name two seed dispersers found in Java, one primate and one other.

2. What do you think is important traits for a disperser to have? Consider size, diet, habitat.

3. Draw what you think Java's forests would look like if important seed dispersers became extinct.

Chapter six: What is happening to pollinators and dispersers

Aims:

1. **Students will learn how pollinators are being negatively affected by humans**
2. **Students will learn how dispersers are being negatively affected by humans**

Learn:

Alarmingly, in many areas of the world, animal populations are declining. As the human population grows, so to does infrastructure, food demands and therefore farm fields, and agricultural practices.

Habitat loss is the conversion of wild meadows or forest to less habitable land. This is frequently done to create space for agriculture, resource extraction or human settlement. Dispersers and pollinators both loose nesting sites, food sources, shelter and safe access to water, the main components to survival. Indeed, some habitats are broken up into smaller, isolated patches which provide some resources. However, they may not be large enough to meet all animal needs. A scarcity of resources will increase competition and reduce survival rates, which can quickly demolish a population. Animals that try to move to new habitat expose themselves to risks of human capture, transport and territorial battles. There is growing evidence that suggests that in areas where pollinators and dispersers are declining, so to are the plants that rely on them for successful reproduction.

Did you know: habitat loss results in a vicious cycle of reduced vegetation, the demise of plant reproductive success and reductions of seed and fruit set. These result in failure of re-vegetation with a level of biodiversity that would have otherwise come about. This cycle applies to all parts of the world where pollination by animals is an integral part of pollination and dispersal.

Indeed, agricultural land can provide new habitat for pollinators, as they provide nectivorous flowers and shelter. However, pollinators ability to habituate these areas are hindered by the common use of chemical fertilizers and pesticides. These are used to improve agricultural practices; however, they are extremely hazardous for animals. Humans included.

Let's look at the difference between organic and inorganic farming:

Action	Inorganic	Organic
Before seed is sown	Fumigate soils with chemicals to kill off any fungicides present	
	Fertilise the soil with a chemical based fertilizer	Throws out a natural fertilizer, such as manure

Planting seeds	Soaks the seeds in insecticides and fungicides before planting them	Seeds are planted in the soil with no prior process
	Insecticides and fungicides mixed into water to kill off any incoming pests	Natural water is used to feed the seeds
Weed control	Spray weeds with weedicide	Kill weeds with flame weeder's, using natural gas. Or remove the weeds by hand.

Pollinators that eat the nectar from plants sprayed with chemicals can become ill and potentially die. A more common side effect than death is inhibited navigation, foraging and reproduction abilities, which in turn affects the pollinators ability to survive. For example, pesticides have been found to be responsible for bee's failure to return to the hive as their navigation is affected. Loss of bees reduces the pollen and honey stores within the hive. Similarly, monarch butterflies are decreasing because milkweed, the plant that they lay their eggs on and predominantly feed, on are being killed by pesticides.

In birds, exposure to pesticides can impede singing ability, making it difficult to attract a mate and reproduce. There have been cases of South American howler monkeys being dyed yellow, making it more difficult for them to avoid predators. They have also been documented to be responsible for many biological deformations in animals, such as slowed reproduction rates in bats.

Pesticides also end up in places that we don't want them to such as our air, water and food. This occurs when rain washes the pesticides of the plants, and into the soil until it is deposited in our water streams. Deformations in aquatic animals are documented as a result, such as reproduction issues in frogs and fish. This water is also consumed, used to wash or grow fresh foods causing side effects in humans and small mammals, such as nausea, headaches and other illnesses. Pesticides and other chemicals used in farming can be considered as dangerous beyond the realms of agricultural pests.

Act:

1. Investigate: students should interview their parents and find out what foods in their house are organic and non organic. They should try find out if their parents know what happens in organic and un-organic farms. They should also see if their parents or guardians know where they source their vegetables from. This information should be reported in their field books. In class, a group discussion can be held on whether or not adults know the difference between organic and inorganic farming. Students should make an informative poster to exemplify the positives and negatives to their selected style of farming in order to take home and present to their parents. This activity will encourage students make their homes pro-organic produce.

2. Organic farming: if you have the resources, it may be beneficial to visit an organic farm. Students should sit and listen. Can they hear any pollinators? If so write or draw them. Can they see any pollinators? Note them in your field book. This activity will help students to associate pollinators with organic farming. This activity can also contribute to designing their own farm in activity 4.

3. Design your own farm: In groups, pairs or individually students should design their own organic farm. They should draw the crops they would have, if they will use pollinators they should include those too. Will there be flowers present? Hedges for pollinator shelter? The students should explain how they plan to plant their seeds and get rid of any weeds. Students should explain their farm to the class and explain why it would will help protect pollinators and dispersers. This activity will get students thinking about how farmers can help to protect Java's biodiversity, rather than harm it.

4. Grow your own: students should choose a vegetable and de-seed it themselves and then plant it. This can be achieved by cutting open a vegetable, picking out the seeds and using kitchen roll to soak up the moisture. Using a spoon move the seeds around so that the moisture is completely soaked up. Leave them to dry for a short while. In a small tub (can be half an old water bottle), fill it with compost make a small hole with your finger about half an inch deep. Put the seed in the hold, cover with compost and gently pat down. The seedling should be watered and left in sunlight. After about three weeks, once they are mature they will need to be transferred into larger pots. Make sure there is holes in the bottom for drainage. In the larger pot, put some compost in, make a hole and insert the juvenile plant. Compact the soil around it so that it can stand by itself and then water it in. Leave it in warmth and sun. This should be followed by activity 5.

5. Make your own fertilizer: students should be given a lesson on how to make organic fertilizer. Use the 'fertilizer recipe' hand-out. They could be separated into groups each to make a different type of fertilizer. They can then use it on their growing seedlings and discuss the difference in growth. You could have a control of a group that used no fertilizer and inorganic fertilizer. Be sure to observe the differences over a long period of time seeming as organic is long term and inorganic is short term. They could also make a recipe posted for display in town.

*** NEEDS A HAB LOSS ACTIVITY

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. Name two human human behaviours that are harming Java's biodiversity.

2. What is the difference between organic and inorganic produce?

3. How can farmers be more friendly to pollinators (e.g. provide shelter).

Chapter 7: How will their loss affect us?

Aims:

1. **Students will learn what an ecosystem is**
2. **Students will learn what challenges an ecosystem**
3. **Students will understand how wild animals are affected when their forest is cut down.**

All living organisms depend on one another to survive. They also rely on non living environments (weather, sun, soil, climate, and atmosphere) to survive.

In class activity: ask your students what humans need to survive? (water, sunlight, air, food, and habitat). Draw or write examples of each of the components on a board and use arrows to explain the relationship between them. See 'ecosystem hand-out' for example.

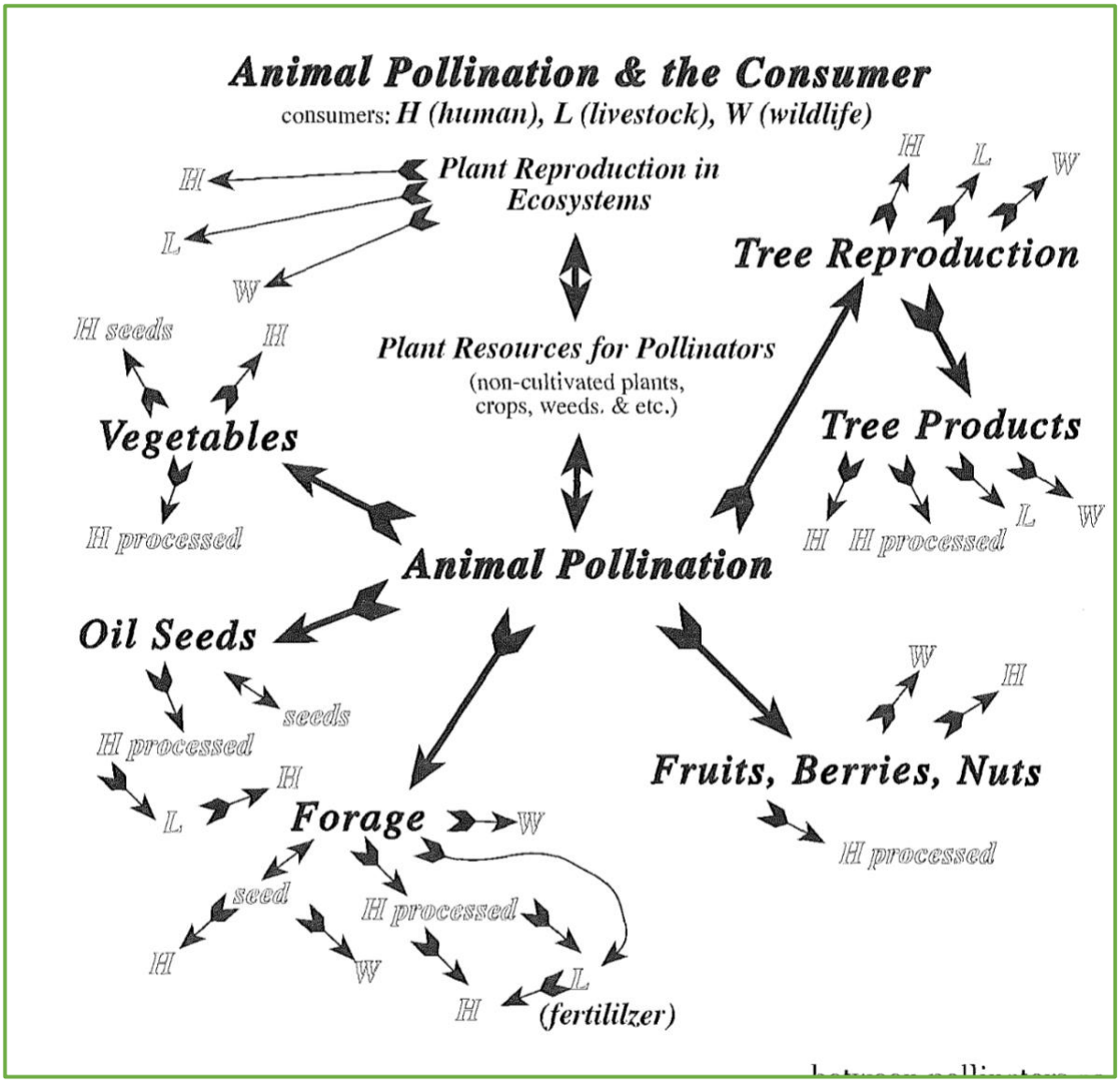
Explain to the class that an ecosystem is a balance of organisms sustaining one another in order to survive. If an organism's essential needs (food, water, air, habitat) are not met, they cannot survive. If one member of the ecosystem is struggling to survive, it will likely affect the other members too. Each organism has its own role to play in keeping the entire ecosystem alive.

In class activity: remove an item from the diagram previously drawn and discuss as a class how the ecosystem will be affected as a result.

Did you know: a healthy ecosystem does many things. It purifies the air so that we can breathe properly, sequesters carbon for climate regulation, cycle nutrients so we have access to clean drinking water without costly infrastructure, regenerates our forests and pollinates our crops so that we don't go hungry. As the worlds population continues to grow, so too does our dependence on a healthy ecosystem to provide necessities essential for our survival.

How would the loss of pollinators affect humans?

1. Humans would be forced to pollinate crops by hand. This would be incredibly time consuming and therefore the price of pollinated foods would increase, and the variety which we see today would decrease.
2. The livestock that is currently fed pollinated plant substances would starve, and the meat and dairy industry would therefore shrink, and become more expensive as human pollination would be required.
3. There would be increased malnutrition across the world as there is less stable access to nutritious fruit, vegetable, meat and dairy.
4. Large industries, such as the cotton and coffee, would collapse causing extensive job loss and possible economic collapse.
5. Loss of natural medicinal plants that aid illness and pain.



Pollinators play an essential role in helping to feed a rising world population in a sustainable way and help maintain biodiversity in a vibrant ecosystem. They contribute to building resilient livelihoods and creating new jobs, satisfying the growing demand for healthy and nutritious food and non-food products.

Most importantly, without pollination plants would not regenerate. Without pollination, seeds would not grow. There would therefore be no seeds to disperse and the landscape would become completely altered. All organisms that use the forest's resources for food, shelter, climate and water becomes scarce. Finally, there would be less oxygen in which to breathe, resulting in all living organism's death.

It is therefore important that deforestation and land development is done sustainably so that we can help protect our ecosystems health.

Act:

1. Ecosystem explorers: on a nature walk, explain to your students that they are going to be 'ecosystem explorers'. They should put dirt, leaves and other objects into sandwich bags. They should also take any photos of small animals and insects that they see. When back in a classroom, print all the photos taken and have students use glue to attach the material that they found to a poster- along with the photos. They should draw lines to show the transfer of energy/relationship between each component. Each poster should be laminated and put on a display titled 'our neighbourhood ecosystem'. Students should explore one another's posters and write a short story about the relationship of organisms in their neighbourhood ecosystem.

2. Parts of an ecosystem: Students should draw an example of a producer, consumer, decomposer, herbivore and carnivore. They can make these into small ecosystem books. This activity will demonstrate the different components of an ecosystem to students. They could use insights learned from activity 1.

3. Food chains: provide students with a sun, and five paper circles. Students should draw an animal of their choice to exemplify the transaction of energy in a food chain. The circles can then be connected by sting and hung around the classroom. This activity will demonstrate to students the reliance of animals on one another to survive.

4. What do you need to survive: Separate your students into groups and explain that they are a team of biologists tasked with determining whether or not the provided habitat is suitable for the provided animal (Use the 'biologist cue cards'). They should consider what is needed for the animal to survive (water, sunlight, air, food, shelter). They should also try to consider if the habitat allows the animal to carry out their normal behaviours, e.g. flying, crawling, or swinging in the day or night time. They should come up with the reasons as to why it is or isn't a suitable habitat and then switch habitats with another group. They should try to assess their animal with each habitat. Be sure to collect each groups list of reasons at the end of class.

5. Human pollination: you should show your students how to self pollinate a flower. To hand pollinate, remove the petals from a male blossom to reveal the stamen at its

centre. You'll see pollen clinging to it. Touch it with your fingers or a small paintbrush and carry the pollen on your finger to to the brush to the female blossom. Touch them at their centre. Discuss how long it would take to pollinate enough flowers that would feed the world.

6. Show and tell: on a nature walk, ask students to select one thing that they believe is good and one that is bad for the environment. The students can physically remove non living organisms, however for living organisms they should take a photo. Back in class they should present to the class or write a short paragraph explaining the reasoning behind their selections. This activity will encourage students to actively identify how they can help protect the ecosystem.

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. What are the four things all organisms need in order to survive?

2. If the bats became extinct, what other organisms would be affected? List or draw them. (Class members could choose between bats, slow loris, gibbon or bee's).

3. Draw a picture of what you think Java's forest would look like if both pollinators and dispersers became extinct.

Chapter eight: How can we help?

Aims:

1. **Students will learn of the ways that they can contribute to pollinator and disperser conservation.**

Learn:

We now know and understand that pollinators and dispersers provide vital services to humans, yet are under pressure due to our own behaviours. As a class, come up with ideas for how we can help protect them. Below are some examples.

Education is vital. Without knowledge of how one is harming biodiversity, the consequences it has and how to avoid these consequences, one cannot be expected to know how to protect Java's biodiversity. Education can therefore be used to teach of the importance of a healthy ecosystem and how to maintain ecosystem health.

Farmers can be educated to:

1. Reduce or eliminate their use of harmful pesticides. If they must be used, directions should be followed precisely.
2. Use organic farming techniques (e.g. compost and fertilizers).

3. Plant hedges at the perimeter of fields to allow food and nesting resources for a large variety of animals, including birds, bats and insects. The hedges can also be pruned for firewood providing multiple benefits.
4. Create field boundaries of selected beneficial plant species for weed, pest and soil control as well as providing alternative food sources of pollinator species.
5. Spend economic resources on improving existing agricultural projects rather than removing more forest to extend agricultural land.

Did you know: worms and beetles can play an important role in agriculture. They recycle soil nutrients, eat live and dead plant, help control weeds as well as insect pests such as slugs, caterpillars and aphids. Invasive beetles can however damage crops by feeding on them. Bats too are also good for controlling insect pest populations, especially in agricultural settings.

Other ways in which we can help is to:

1. Grow a variety of flowers in your garden. By having a diversity, you may be providing pollinators with nectar in times when there are low levels of other resources.
2. Make wise consumer choices, such as purchasing organically grown produce.
3. Respect, and encourage others to respect wild animals and their habitat.
4. Contribute to reforestation and restoration projects (e.g. donating/planting trees).
5. Use sustainably sourced wood products (paper and timber)
6. Provide connection between habitat fragments to allow species exchange and migration.
7. To join and support organisations that increase public awareness about the importance of, and how to protect pollinators and dispersers and their habitat.

Act:

1. Dear Mr.: students should pen a letter to an inorganic farmer explaining the reasons as to why they should change to organic farming. Students should include how they can improve their inorganic farm in the meantime.

2. Pledge: on a wall in your school, or on a large piece of paper students should dip their hand in paint and then print it on a clean surface. Once dry, students should make a pledge to Java's biodiversity. If it was done on paper, this can be put on display in town or somewhere where people beyond students can observe the pledges.

3. Poster: students should create a poster to exemplify their thoughts on organic and inorganic farming. These should be displayed as an exhibit in town. Students should think of these posters purpose as to educate the wider public about pollinators and the need for their protection.

4. Plant a tree: as a class, you could plant a tree as a pledge to the environment. Students could also write down a pledge, and draw a picture of how they want Java to look in the future and bury it in a time capsule below the tree.

5. My favourite thing about the forest: on a nature walk, students should be provided with time to themselves to listen and watch the forest. The should make sketches of things that they like best about the forest. They should explain why they like what they do to the class.

6. Their home is our home: on a nature walk, explain to the students how the forest is the animals home. Like ours, it provides food, warmth, shelter and friends. Half of the class should draw their understanding of what makes a home to them, and the other half should draw what they think makes a home to an animal of their choice. As a group, you should consider the similarities and differences between the homes of humans and non-humans.

Reflect:

Answer the following questions individually, and then as a class discuss them.

1. Name two things that we can do to protect Java's forests.

2. Draw a pollinator friendly farm.

3. Draw a picture of how you want Java's forests to look like in 30 years' time.