Opwall Schools' Booklet
Fiji 2019

Contents

1. Study area and research objectives

This expedition is split between two main field sites on the Fijian Island of Vanua Levu in the South Pacific. The first week is spent at a forest camp within the lowland tropical forests of the Island. The second week is spent at the Natewa Bay Marine Research Centre within Natewa National Park.

Figure 1. Map of Fiji showing main locations students stay or transit through

Fiji is comprised of a group of mountainous islands in the South Pacific, 1,300 miles (2,000km) northeast of New Zealand. The islands of Fiji were formed approximately 150 million years ago through volcanic activity. In fact, most of mountains in Fiji are dormant or extinct volcanoes. Fiji's climate is warm and tropical year-round, even in the islands' "winter" months. The average temperature in Fiji is 25°C (77°F), but it can climb to above 30°C (86°F) in summer (December and January) and sink to 18°C (64°F) in winter (July and August). Heavy rains (up to 304 cm or 120 inches annually) fall on the windward (south-eastern) side, covering these sections of the islands with dense tropical forest.

Only 106 of the 332 islands and 522 islets, which make up the Fijian archipelago, are permanently inhabited. The two largest islands are Viti Levu and Vanua Levu and between them they make up 87% of Fiji's landmass. The Operation Wallacea research site is based on the island of Vanau Levu which is the second largest island in the archipelago and covers just over 30% of the country's land area. Despite its size, this island is home to only 15% of the Fijian population.

The tropical forests of Fiji contain some of the richest communities of flora and fauna of all the oceanic islands of the Pacific. Moreover, their unusual biogeographical history, complex topography and relative isolation has led a large number of the species found in Fiji to be endemic. Over half of all Fiji's vascular plants are endemic, many of which are confined to a single island or single site, including some of the world's most primitive plant species. Twenty-five birds occur only in Fiji and most of the reptiles,

amphibians, bats, and invertebrates are unique to the islands. Because many of the species found in Fiji are restricted to only one or a few islands, they are vulnerable to human disturbance.

3,300 to 4,000 years ago the islands of Fiji's were first colonised by Polynesians and Melanesians. The current population of Fiji stands at approximately 880,000 and is rapidly growing. A rapidly growing population is often a key driver of deforestation. The FAO Global Forest Resource Assessment (2010) estimates Fiji's forest cover to be 56% of the total land area (1,014,0800 ha). Alarmingly, since the 1960's about 15% of the forests in Fiji have been completely cleared. 87.9% of the land is Fiji is communally owned as "iTaukei land" through traditional Fijian landowning units called Mataqali (pronounced matangali). As such, the state have limited control over land use or have the ability to designate protected areas or reserves. In Fiji, approximately only 68 km2 of moist forest is currently protected in reserves. This reserve system protects less than 1% of remaining forests and there is a strong need for reserves on islands to protect regional endemics.

The Peninsula is geologically and biologically an 'almost island' that is 60km long and averages over 10km wide. At its eastern end it is 10km from Taveuni Island, and at its western end (where it is connected by a narrow neck of land to Vanua Levu) the peninsula is only half a kilometre wide. The Natewa Peninsula is the wildest remaining area in Fiji with forests still containing some of the largest native trees and with the highest floristic and faunal diversity in the Fijian islands. It is also home to a number of the Fijian endemic species including the Silktail Flycatcher which is found only on the peninsula and in one small island offshore.

Background and previous surveys

In 2013 the Nambu Conservation Trust decided to create the first community managed National Park in Fiji on their mataqali land (mataqali are land owning family groups). This was an important step since >95% of the best remaining forest on Fiji is mataqali land. The neighbouring Vusaratu mataqali also agreed to include their land in any protected area development and to participate in these surveys. In 2017 the first surveys were conducted in this area by the Opwall teams and these concentrated mainly around the Natewa forest camp. In 2018 though whilst based at the same camp the teams were much more mobile and began to explore other areas of the peninsula and the results from these two years of surveys were published as a report on the biological value of the Natewa peninsula (see https://www.opwall.com/uploads/2018/12/The-Biological-value-of-the-Natewa-Peninsula.pdf).

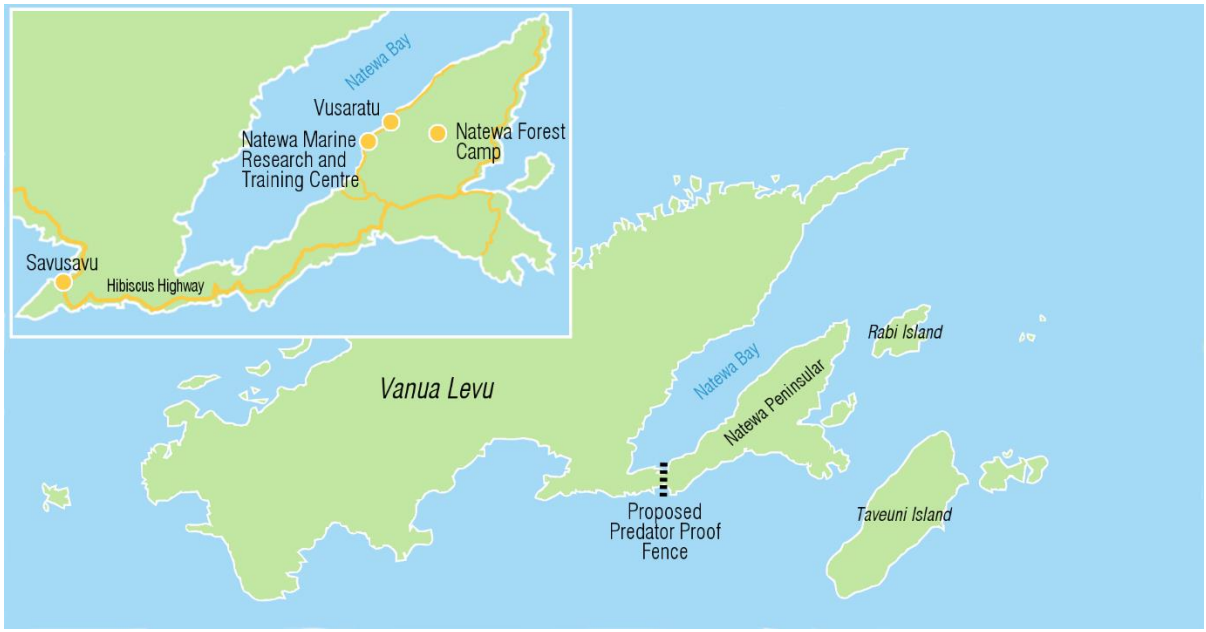

Figure 2. Research locations in Fiji during 2017 and 2018

The main findings over the two years of the surveys have been:

- The Natewa Peninsula encompasses approximately 55000 ha of the south-eastern section of Vanua Levu, Fiji, and retains large expanses of tropical lowland and hill forest.

- The biodiversity of the Peninsula possesses an extremely high conservation value. To date, a total of two native mammal species, 48 bird species, 10 herpetofauna species, 13 butterfly species, 61 gastropod species, and 84 tree species have been detected in the study area.

- This diversity is impressively representative of species assemblages across Fiji as a whole, given the size of the study area. The Natewa peninsula comprises only around 3.1% of the total land area of the Fijian archipelago, but 59% of terrestrial birds, 33% of native terrestrial mammals and 35% of reptiles known to occur nationally have been found here.

- Faunal groups in the Natewa Peninsula also display high incidence of endemism, with 31.3% of birds (15 species), 33.3% of herpetofauna (three species) 30.7% of butterflies (four species) 36.1% of gastropods (22 species) and 31% of trees (26 species) found here being entirely restricted to the Fijian archipelago.

- Numerous species are also very locally endemic to the study area. These most notably include the Natewa Silktail (*Lamprolia klinesmithi*) and Natewa Swallowtail (*Papilio natewa*),which are both entirely restricted to the study area. Note the Natewa Swallowtail butterfly described by the Opwall teams is the first new swallowtail butterfly described to science in over 50 years and wasn't discovered as expected from somewhere like the Amazon or Borneo but from a remote forest site in Fiji!

- A further six species and five sub-species found in the study area are endemic to Vanua Levu and its offshore islands.

- The forests of Natewa also provide valuable ecosystems services, both locally to communities living in the Peninsula via flood prevention, soil protection and crop pollination, and also to global society through the carbon stocks they sequester. Initial analysis put carbon stock estimates in the study area at 20,732,148 metric tons.

- The diverse ecological communities of the Natewa Peninsula are, however, highly threatened by anthropogenic pressures. Unregulated deforestation and forest degradation is extensive in the study area. Introduced Cane Toads, rodents, and most significantly the Small Indian Mongoose (*Herpestes auropunctatus*) also represent a serious threat to ground-nesting birds, reptiles, and other native wildlife. Between 175,000 and 400,000 mongooses are estimated to occur on the Peninsula.

- The urgent conservation status of biodiversity here (and the Fijian archipelago generally) is demonstrated by the number of threatened species present in the Natewa Peninsula. One native mammal, two herpetofauna species, and two tree species are considered by the IUCN to be globally Endangered. A further two bird species, one lizard, six gastropods, and two trees are considered to be Vulnerable, and one mammal, one bird, two gastropod and one tree species are considered to be Near-threatened. Particularly notable examples of threatened species include the Endangered Fijian Free-tailed Bat (*Chaerephon bregullae*) and the Vulnerable Natewa Silktail (*Lamprolia klinesmithi*), and Shy Ground Dove (*Alopecoenas stairi*).

These initial surveys have led to great excitement amongst the local mataqali, regional government and large NGO's such as BirdLife International about the prospects for protecting these areas to attract tourists to see the unique fauna of the peninsula. BirdLife had already identified the Natewa forests as an Important Bird Area and had started work on getting ecotourism income to some of the mataqali, but numbers of visitors to date (other than through the Opwall programme) had been very low. In order to bring in good numbers of visitors, the development of a marine research centre on the peninsula would also be necessary since many visitors to the islands want to snorkel or dive. The building work done by Opwall has created the basis for a marine centre.

In 2018 a funding application to employ a team of local people to run an intensive trapping programme to remove the mongoose has been submitted. If a national park were to be created then reduction or elimination of any invasive species that has significantly reduced the native amphibians, reptiles, ground birds and snail fauna would be a necessary first step. However, simply removing mongoose from the peninsula would only be a temporary measure unless repopulation from the rest of the island was prevented. The Glenelg Trust, a wetland biodiversity protection NGO from Australia are working with Opwall and the Wallacea Trust to investigate the cost and funding for installing an invasive proof fence across the narrow neck of the peninsula in the same manner has been done extensively in parts of Australia and New Zealand. The lead scientist from the Glenelg Trust on the Natewa project was the person responsible for designing the Yorke peninsula project in Australia (see http://theleadsouthaustralia.com.au/environment/feral-proof-fence-drives-biodiversity-revival/).

2019 forest research objectives

One of the best ways of generating income from protecting forests is to use funding sources such as REDD+ where a forest is packaged according to the carbon value, biodiversity and societal benefits and regular payments are made from a REDD+ fund to maintain the forests in their present condition. The REDD+ funds are provided by wealthy nations to the forestry departments of developing countries to ensure the forests are maintained and the carbon saved from not logging the funded forests is then counted towards the donor nations national carbon budgets. In 2018 carbon measurements were obtained from 30 study plots spread across the peninsula. It was hoped that the satellite imagery of the peninsula could be classified to produce maps of different forest types, but this proved impossible. The estimate of 20 million tonnes of carbon held in the Natewa forests was therefore calculated simply by multiplying the average carbon value across all the plots and multiplying it by the total forest area. Since truly random selection of forest plots is not practicable (due to site inaccessibility with sheer cliffs in some places and the forest ownership spread amongst 51 different mataqali requiring protracted negotiations with each to gain access) then this estimate may be biased by the overall plot selection. It was noted though in 2018 by the forest teams completing the carbon measurements in each plot, that after a short period of completing these measurements that the surveyors could estimate the carbon value by eye to within 20% of the measured value. This means that it should be possible to produce a map showing the distribution of forest in at least 4 different carbon categories by sampling as many of the 550 x 1km x 1km squares that cover the Natewa peninsula as possible and tying this to satellite data. The forest classification and mongoose impact survey team will be doing this during the 2019 season. Quantifying the total area of forest in each of 4 different carbon classifications will then allow data from 20m x 20m squares in each of those forest carbon categories to be used to calculate the average for each category. This mobile team will also help identify the presence in particular areas of some of the target species such as the Friendly Ground Dove which is a Fiji & Western Polynesia endemic and which has previously been recorded from the Natewa forests but has a very restricted distribution. This species has been in decline throughout its range and in the case of Natewa, this may be due to high numbers of mongoose. A second species is the Long-legged Warbler, which is known from only 4 specimens collected between 1890 and 1894 on Viti Levu and a single specimen from Natewa in 1973. On Viti Levu there is a known small population occurring on steep sided forested slopes (presumably where they can still survive in the presence of mongoose) but the bird has not been seen on Vanua Levu since 1973. It may be extinct on the island but the opportunity to send in teams of experts to remote forests in the Natewa peninsula probably gives as good an opportunity as any to determine whether this species still exists.

The new species of swallowtail butterfly has caused great excitement in the butterfly world but is only known from one area of the peninsula at the moment – finding additional areas where this species occur would be invaluable. In addition, there are reptile, gastropod and a bat species that are all threatened and which have been recorded on the peninsula, so any information about their distribution across the peninsula would be valuable.

The bird survey team will be following up any sightings of the target bird species but also re-surveying a series of standard transects to compare numbers of all the Natewa bird species between years, as well as continuing with the mist netting to compile data on the plumage configuration and morphometrics on the Fiji endemic species and information on breeding season and longevity.

The invertebrate survey team will be following up any records of the target gastropods and the Natewa Swallowtail butterfly from other parts of the peninsula but also helping with completing an illustrated guide to the larger invertebrate species that can be used for visitors to the proposed park.

The forest structure and carbon team will be completing additional data collection on 20m x 20m squares in each of the forest carbon categories.

2019 marine research objectives

The Fijian Archipelago hosts a highly diverse and extensive marine environment encompassing an array of different marine habitats including; barrier and fringing coral reefs, mangroves, deep pelagic areas, and eelgrass beds. These habitats are considered to be internationally important sites for marine biodiversity and support numerous fish species, turtles and nesting seabirds. It is argued that the coral reefs of this region have some of the most species rich assemblages in the world. The waters of the Fiji contain 3.12% of the World's coral reefs including Cakaulevu, the Great Sea Reef, which is the third largest coral reef in the world. Marine life includes over 390 known species of coral and 1,200 varieties of fish of which 7 are endemic. Currently 25% of Fiji's waters have some form of protection or marine management plan.

Natewa Bay, which at over 1000 km^2, is the largest bay in the South Pacific, bounds the northern part of the Natewa Peninsula. This bay has very low levels of fishing pressure and some superb reefs. Moreover, due to geological faults the centre of the bay is over 1,000m deep. Amazingly, no biological surveys have ever been completed on this bay. The concept of the proposed Natewa National Park is not just to protect the forests of the peninsular but also the waters and reefs of Natewa Bay. Having both a marine and a forest element to the proposed National Park would make the Park are more popular destination for visitors.

In 2019 the objective is to establish a series of transects that will be monitored annually for fish diversity and abundance using stereo video and to examine any changes occurring in the reef structure using 3D modelling from data collected using Go Pros.

2. Week 1 itinerary for Schools at the Forest Camp

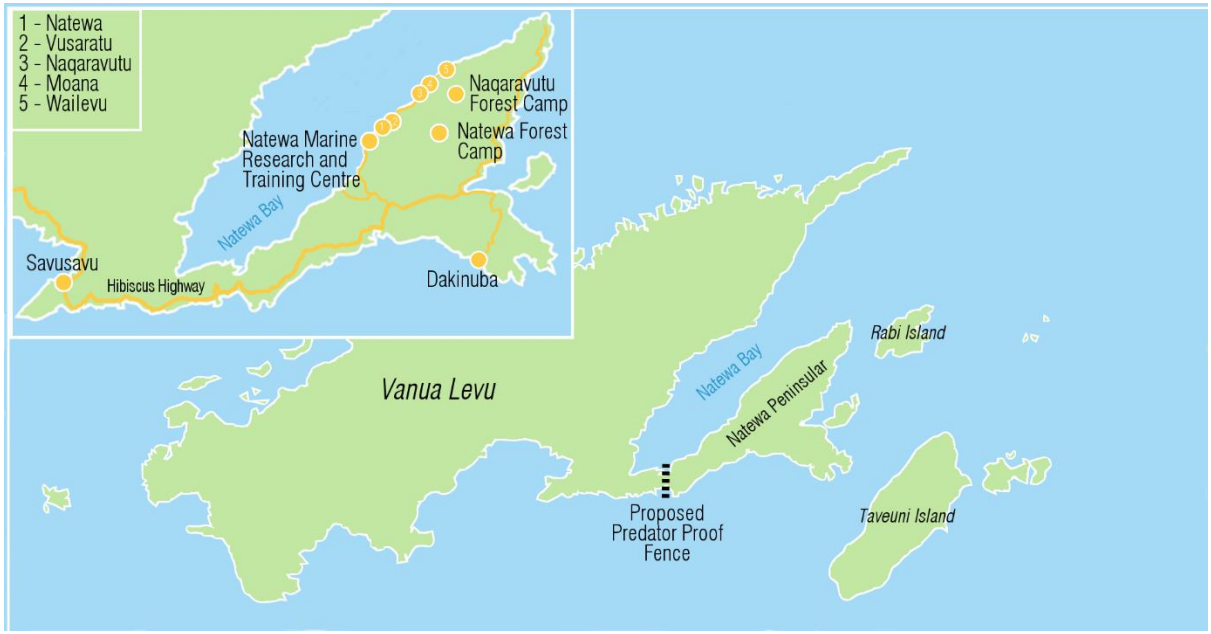

Figure 3 – position of the camps and communities in which the Opwall teams will be based for 2019 survey season

Groups arrive in Fiji on the Saturday before their expedition officially starts on the Sunday afternoon. The groups need to be catching the 1130hrs flight from Nadi to Labasa on the Sunday morning. Some groups will therefore arrive into Nadi and overnight at a hotel on the Saturday whilst others (eg those arriving from the west coast of the US) have an early morning arrival into Nadi which allows them sufficient transfer time to catch the Sunday morning flight to Labasa. The groups are met in Labasa and taken by bus (approximately 2.5 hours) to the pretty coastal town of Savusavu where they will have a late lunch. After lunch the bus will travel the remaining 2 hours to one of the Fijian coastal villages arriving in the late afternoon on the Sunday. To enable acclimatisation to the area and rest before trekking into the forest, groups will enjoy a home stay with the local community in a traditional Fijian village for the first two nights. Note in order to spread the financial benefit of this income a few different villages are being used including Vusaratu, Natewa, Naqaravutu and Dakinuba

On Monday, the students have the opportunity to participate in the activities that make up daily life in a Fijian village, starting with cooking their own lunch in an earth oven. They learn about the traditional crafts such as mat weaving and tapa making through hands-on workshops with the local women, and then have some free time in the afternoon to play volleyball or the local game of *pani* with the children. The day concludes with a farewell party that usually includes singing, dancing, and if the weather permits, a bonfire.

In the early morning of the second day those groups allocated to main Natewa forest camp will trek up the hills onto the forest plateau at around 800m above sea level and will be staying in a forest camp for the next 4 nights. Different groups of students will join different biodiversity surveys each day to ensure that all students get the chance to work with each of the different teams. Some projects will involve travel by lorry and then trekking into the forest for an early morning start. For these projects the teams will be in the field all day and returning to the camp for dinner. After dinner there will be a lecture from the Pacific Island ecology lecture series.

Note there are a couple of weeks where teams will need to be based in one of the more distant villages for the whole week and from there working into the nearby forests from the homestays. For example, when surveying the forests of Dakinuba it is easier to be based in the village and work from there then have to commute each day.

Table 1 – Indicative timetable for the first week. Note there may be changes to this itinerary depending on fitness of students, weather conditions or operational issues on site and the exact order of activities throughout the week may differ from the proposed timetable below.

Day	Activities team A	Activities team B	Activities team C	Activities team D
Sunday afternoon	Welcome lecture Health and safety briefings			
Sunday evening	Home stay in traditional Fijian village			
Monday	Talks and practical demonstrations of Fijian culture, customs and agriculture			
Monday evening	Lecture 1: Geography, geology and island ecology Homestay in traditional Fijian village			
Tuesday morning	Early morning trek up to forest camp (2 -4 hrs) and camp orientation			
Tuesday afternoon	Forest structure and carbon surveys	Butterfly and other invertebrate surveys	Bird surveys	Forest classification and mongoose impact surveys
Tuesday after dinner	Lecture 2: Dispersal and colonisation			
Wednesday morning	Forest classification and mongoose impact surveys	Forest structure and carbon surveys	Butterfly and other invertebrate surveys	Bird surveys
Wednesday afternoon				
Wednesday after dinner	Lecture 3: Terrestrial biodiversity			
Thursday morning	Bird surveys	Forest classification and mongoose impact surveys	Forest structure and carbon surveys	Butterfly and other invertebrate surveys
Thursday afternoon				
Thursday after dinner	Lecture 4: Humans, extinctions and invasions			
Friday morning	Butterfly and other invertebrate surveys	Bird surveys	Forest classification and mongoose impact surveys	Forest structure and carbon surveys
Friday afternoon				
Friday after dinner	Lecture 5:Disturbance and climate change			
Saturday morning	Forest structure and carbon surveys	Butterfly and other invertebrate surveys	Bird surveys	Forest classification and mongoose impact surveys
Saturday before lunch	Lecture 6: Conservation			
Saturday afternoon	Transfer to marine site			

3. Forest Structure Measurements

There are two teams working on this aspect of the survey. The first team is the forest classification and mongoose impact team and this team will be visiting as many parts of the peninsula as possible to classify the forest in each 1km squares into one of four carbon standing crop categories. The team will be trekking through the different areas to determine the status of the forests and plotting the boundaries of the different carbon categories by GPS and then transferring those data onto a GIS map of the peninsula. In each of these 1km squares this team will also record the presence of Natewa Swallowtail, Natewa Silktail, Long legged Warbler, Friendly Ground Dove, Orange Dove, Maroon Shining Parrot, Fiji Wattled Honeyeater, Fiji Banded Iguana, Fijian Monkey-faced Bat, and large endemic snail species such as *Trochomorpha merzianoides, Callistocharis elobatus* (Gould, 1846) and *Callistocharis fulguratu.*

The second forest structure team will be completing detailed forest mensuration in 20m x 20m squares in each of these 4 different carbon classifications. The number of saplings (trees with circumference $<$15cm and a minimum height of 2 metres) will be counted for each plot. For each tree in the plot with a circumference $>$15cm, the circumference at breast height (which will be converted to DBH), whether the tree is alive or dead, and the tree species, will be recorded on datasheets. Where species cannot be identified in the field, photographs of leaves, fruit (if available leaves and bark will be taken for later identification from textbooks. If identification is not possible from photographs, then samples may be taken from the tree at a later date for full examination. CBH will be measured using 50m tape measures. The number of fallen trees and cut stumps in the plot will also be recorded.

Forest structure measurements include understorey vegetation, canopy cover and leaf litter depth. To measure understorey vegetation, the plot will be bisected to produce the four quadrants. A 3m pole marked in 0.5m segments will be used to record the number of vegetation touches on the pole in each 0.5m segment up to a maximum of 10 touches, every 1m along these bisecting tapes. If one of the positions coincides with a tree then each of the 0.5m segments will be recorded and having vegetation touches. The openness of the canopy will be measured by taking a reading with a canopy scope facing the largest opening in the canopy from the centre of each of the four quadrants and one from the centre of the overall 20m X 20m square. If any of these points is closer than 1m to a tree trunk, then the observation point should be moved slightly so that it is at least 1m from the nearest tree trunk. The perspex square has 25 dots engraved on the square. The observer should look upwards holding the square 20cm from the eye count the number of dots that coincide with gaps in the canopy to give a score out of 25. Leaf litter depth should also be recorded in each of the 4 quadrants and in the centre of the plot using a ruler to give 5 separate leaf litter measurements (mm) per plot.

4. Biodiversity Monitoring

Butterfly and other macroinvertebrates

This team has two different objectives. The first is to complete more detailed Pollard counts of butterfly communities in different habitat types to determine the relative abundance and habitat associations of the various species. In particular, more information is needed on the newly described Natewa Swallowtail *(Papilio natewii)* and whether this species occurs more widely across the peninsula.

In addition, though what is needed is more information on the other macro-invertebrates in order to produce an illustrated guide to the macro-invertebrate fauna of the peninsula. This will involve the teams using a variety of methods: sweep netting, light traps, pitfall traps, flight intercept traps etc.

Bird surveys

Bird data will be collected using point counts and mist netting from around the Natewa forest camp to compare the data with the 2017 and 2018 surveys. The point count surveys will be completed between 05:00am and 09:00am. If it is raining heavily or there are strong winds the survey should be cancelled. On all surveys the weather conditions at the time of the point count should be recorded. Point counts of birds (by sight or call) will be conducted at 10 different points along the transect a 200m intervals. No settling down period should be allowed with counts starting immediately. Then over the next 10 minutes for each species the following details should be recorded: species, number of individuals, whether the bird(s) was seen or heard, and the approximate distance of the bird from the observer (recorded at 5m intervals).

The abundance and diversity of understory birds will also be assessed using mist nets. Mist nets are unable to sample canopy and mid-canopy species adequately, but does allows for quantitatively reliable data to be produced for tropical understory birds, allows for the identification of birds that are shy or seldom vocal, minimises observer bias, and produces results that are easily repeatable. Mist nets surveys will run 2 days per week at the Natewa forest camp using a suitable existing clearing along one of the sample routes with enough space to erect two 12m long mist nets 2.5 meter high. The location of this mist net site will be marked and the GPS location recorded. The opening and closing time of the nets will be recorded each session and nets will be checked every 20 minutes for the duration of the survey. When birds are found in the net, the time of capture will be noted. The birds will be taken out of the net, placed in a cotton bag for holding whilst other birds are being processed. Ringing will be used to control for recaptures. The birds will be weighed (to the nearest gm), standard morphological measurements taken and New Zealand ring attached. The birds will be released close to the net site but far enough away to avoid them being immediately re-trapped.

The other part of the bird surveys though will be to visit a range of forest sites encompassing different forest types across the peninsula. To compete point counts at these sites the teams will need to leave camp well before dawn so that they can arrive at the start of the transect to be surveyed by dawn. After completion of the point counts the bird team will carry on trekking to record additional data on the bird fauna.

5. Pacific Island Ecology lectures

This lecture series has been prepared by Professor Martin Speight from Oxford University and is based entirely on published papers on Pacific Islands over the last 10 years. The examples given in the lectures are referenced to primary sources and there are full notes below each slide. The teachers will have a copy of these lectures and the PowerPoints so that these can be repeated, if required, back at school or delivered to other classes that did not join the expeditions. The lectures however, will be delivered as a series of stories, rather than including all the details of each publication, so that the students gain an understanding of the ecology of the islands.

6. Learning outcomes from week 1

The students should achieve the following learning outcomes from the fieldwork, practical's, lectures and discussions/activities:

- Be able to define and understand the main Fijian habitats.
- Have an insight into the ecological and cultural heritage of Fiji
- Understand the meaning of Biodiversity and the importance of the area as a biological hotspot.
- Consider how island species may have evolved and spread.
- Understand the importance and use of taxonomy and classification in field research work.
- Use (taxonomic) keys to identify taxa such as butterflies and birds (and understand how different populations are determined from field data).
- Understand the impact of alien/invasive species on island populations.
- Understand the threats and conservation issues in Fiji
- Be able to identify common island bird species.
- Describe and carry out survey techniques for butterflies and other macro-invertebrates.
- Consider the impacts of humans on the flora and fauna of Fiji

7. Week 2 Itinerary

The students will complete six days of training in marine ecology at Natewa Bay Marine Research Centre. The work of Operation Wallacea is helping to establish a marine research centre and groups will be staying in two-person tents with views of the bay.

At Natewa Bay Marine Research Centre the students have the option of completing their PADI Open Water dive qualification (see section 9). If they are already dive trained or don't want to learn to dive then they can do the Pacific Reef Ecology Course (with the practicals done either by diving or snorkelling – see section 8). Note some of the practicals involve working with the marine biologists on site who are completing 3D modelling of the reefs. A third alternative is to complete their theory and confined water practicals before coming out and then just do their 4 open water dives to achieve the PADI Open Water qualification (see section 10) and then move onto the reef ecology course. Students will be occupied in the evenings through a series of science talks, documentary viewings and discussions/activities relative to the ecology course.

8. Coral Reef Ecology Course

Table 2 shows an example timetable of the activities that students undertaking the Pacific Coral Reef Ecology Course will complete over the week. The contents of the timetable are comprehensive but the timing of the sessions will vary for each group. The practical element of the reef ecology course can be completed by either diving or snorkelling. If students are already qualified divers by the time they arrive on site, they will be required to complete a compulsory check dive with a PADI Professional at the start of the course. The Pacific Island Coral Reef Ecology course is designed specifically with 16 – 18 year old high school students in mind. It covers a range of topics suitable to support A-Level and international equivalent biology and geography students over a range of different syllabuses. Lectures will be supported by in-water practicals. In addition to the lectures, a discussion/activity element will be sure to engage the students and get them thinking themselves of the importance of the study topic.

Table 2. Indicative timetable for students completing the Pacific Island Coral Reef Ecology Course. Note there may be changes to this itinerary depending on fitness of students, weather conditions or operational issues on site and the exact order of activities throughout the week may differ from the proposed timetable below.

Day	Schedule for reef ecology students
Saturday afternoon	Welcome lecture Allocation to groups for diving and practical sessions Dive documentation
Saturday evening	Lecture 1 – Introduction to coral reef ecology Designation of mini projects
Sunday morning	Check dive/snorkel Lecture 2 – Identification of coral and algal Species
Sunday afternoon	Dive/snorkel practical 1 – algal identification skills
Sunday evening	Lecture 3 – The importance of mangrove and seagrass habitats
Monday morning	Dive/snorkel practical 2 – coral identification skills Lecture 4 – Identification of ecologically important invertebrate species
Monday afternoon	Dive/snorkel practical 3 – coral identification skills
Monday evening	Lecture 5 – Identification of coral reef fish
Tuesday morning	Dive/snorkel practical 4 – invertebrate identification skills Lecture 6 – How to survey a coral reef
Tuesday afternoon	Dive/snorkel practical 5 – fish identification skills
Tuesday evening	Lecture 7 – Global threats to coral reefs
Wednesday morning	Dive/snorkel practical 6 – stereo video surveys Lecture 8 – Methods to protect the world's coral reefs
Wednesday afternoon	Practical 7 – Lab session analysing stereo video fish data
Wednesday evening	Lecture 9 – Conservation project strategies
Thursday morning	Practical 8 - 3D modelling of reefs using video
Thursday afternoon	Practical 9 – Lab session completing 3D model of reef
Thursday evening	Practical 10 - Lab session analysing stereo video fish data
Friday morning	Practical - Lab session completing 3D model of reef
Friday afternoon	Packing
Friday evening	Documentary/film viewing
Saturday am	Depart Natewa Bay Marine Research Centre

Lecture 1: Introduction to Coral Reef Systems

- Why are coral reefs important?
- What are coral reefs and how are they formed?
- Where are coral reefs found?
- Types of coral reefs
- The different zones of a coral reef
- Reefs of Fiji

Activity 1: General feedback session on dive skills and their experience on the reef.

Practical 1: 'Reef Structure and Topography': Check dive/snorkel – PADI Skin Diver course with DM

Lecture 2: Coral Reef Primary Production

- Competition for space on coral reefs
- Scleractinian (hard) corals as ecosystem architects
- Macroalgae (seaweed) distribution, morphology, and their use of pigments
- What happens when the balance between corals and algae goes wrong?

Activity 2: Primary Productivity Quiz
Practical 2: Coral and algal identification skills (DIVING/SNORKELLING)

Lecture 3: The Importance of Coral Reef Fish

- The coral reef food web
- Identification and ecology of common reef fish families
- Common Pacific reef fish species
- Feeding guild examples and key species
- Specialists
- Fisheries exploitation

Activity 3: Fish Quiz
Practical 3: Fish identification skills (DIVING/SNORKELLING)

Lecture 4: Coral Reef Invertebrates

- What is an invertebrate?
- Taxonomy
- Marine invertebrate feeding ecology
- Common marine invertebrates found on coral reefs
- Case study: The Crown of Thorns Starfish

Activity 4: Reef Invertebrate Quiz
Practical 4: Invertebrate identification skills (SNORKELLING)

Lecture 5: How to Survey a Coral Reef

- Why do we survey coral reefs?
- Which method(s) to use?
- Rapid habitat surveys
- Benthic and invertebrate assessment techniques
- Fish assessment techniques
- Measuring abiotic factors
- The use of technology
- The Operation Wallacea reef monitoring program

Activity 5: Survey Design Challenge
Practical 5: Underwater survey techniques 1 (DIVING/SNORKELLING)

Lecture 6 – The Ecology of Seagrass and Mangroves

- The ecology of tropical seagrass beds
- Seagrass importance and threats
- The ecology of mangroves
- Mangrove importance and threats
- Habitat connectivity

Activity 6: Debate: Hotel Owner versus Conservationist
Practical 6: Underwater survey techniques 2 (DIVING/SNORKELLING)

Lecture 7: Global Threats to Coral Reefs

- What should a healthy reef be like?
- Anthropogenic impacts on coral reefs(overfishing, pollution, tourism . . . .)
- Natural impacts on coral reefs(temperature, storms, disease, acidification . . . .)

Activity 7: Discussion Activity: The Global Aquarium Trade
Practical 7: Assessing coral reef health (DIVING/SNORKELLING)

Lecture 8: Marine Conservation

- The value of coral reefs (re-visited)
- Top down management (MPAs, zonation, ICZM)
- Bottom up management (ownership, education, community involvement)
- Alternative livelihoods

Activity 8: Fun Quiz!
Practical 8: Fun Dive!

9. PADI Open Water Diver Course

This course consists of three different elements of learning; dive theory (knowledge development), confined water dives and open water dives. Each component plays its own role in the students' development to meet the performance requirements and objectives they need to become a qualified diver.

Please be aware that as a part of the PADI Open Water Course, all students will be required to complete some basic stamina tests on site. Student divers will need to demonstrate that they can comfortably maintain themselves in water too deep in which to stand by completing a 10-minute swim/float without using any swimming aids. Instructors will also have students complete a 200m continuous surface swim or a 300 m swim with mask, fins and snorkel.

Table 3. Indicative timetable for students completing the PADI Open Water Course. Note there may be changes to this itinerary depending on progression through the course, fitness of students, weather conditions or operational issues on site.

Day	Activity
Saturday afternoon	Welcome lecture Allocation to groups for diving and practical sessions Dive documentation and dive theory
Saturday evening	Lecture 1 – Introduction to coral reef ecology
Sunday am	Confined water
Sunday pm	Confined water
Sunday evening	Dive theory + lectures
Monday am	Confined water
Monday pm	Open Water 1
Monday evening	Dive theory
Tuesday am	Open water 2
Tuesday pm	Open water 3
Tuesday evening	Dive theory exam
Wednesday am	Open water 4 & Dive certification
Wednesday pm	Fun dive!
Wednesday evening	Lecture 9 – Conservation project strategies

Thursday morning	Fish ID Dive
Thursday afternoon	Fish ID Dive
Thursday evening	Mini project presentations/Documentary
Friday morning	In water activities via snorkelling
Friday afternoon	Packing
Friday evening	Documentary or 'Trivia Night'
Saturday am	Depart Natewa Bay Marine Research Centre

10. PADI Open Water Referral Course

For those students who have completed both the dive theory and confined water sessions prior to expedition they can complete their PADI Open Water Referral Course on site. The students will first complete a check dive with their instructor to demonstrate that they still remember and can confidently perform the necessary skills to progress on to complete their open water dives.

Once referral students have successfully completed the final stages of their PADI Open Water course, they will be able to progress on to the Coral Reef Ecology course Although there will not be enough time to run the full course, referral students will be able to join at a stage where they can get the chance to learn about the application of survey techniques in the marine environment and how that supports the management of coral reefs.

11. Academic Benefits

Apart from the most obvious values of going on an expedition such as contributing towards conservation, the physical challenge and adventurous travel, the experience can also benefit a student by increasing their chances of gaining entry to university or being successful in a job application and impressing at interview. This can be achieved in many different ways but it will often depend upon which country and educational system a learner is from. Common to most countries the experience will:

- Enhance their understanding of course syllabuses
- Allow learners to gain specific qualifications such as:
- Research Qualifications e.g. Extended Essays for IB and UK EPQs
- University Course Credits
- Creativity, Action and Service (CAS) for IB
- Universities Award from ASDAN

IRPs or Individual Research Projects

In the last few years an increasing number of students joining our research programmes take this opportunity to undertake IRPs. These research projects take many different forms, but what they all have in common is the need to pose and answer a research question. Examples of these include Extended Project Qualification (EPQ), Extended Essay (EE) for IB, as well as many different projects specific to various education systems worldwide.

We can support a selection of different topics for either essay-based research projects or data-led research projects that are tailored towards what the students will experience on site. It is a fantastic opportunity for

a student to witness first-hand many of the aspects of their research question and, in many cases, they will have access to samples of past datasets for their project. Students may also have the opportunity to talk with the actual scientists involved which will give them a convincing 'slant' to the way in which they answer their research question.

For success with IRPs, careful planning is needed by the student and a lot of the work will be done prior to their expedition. They will need close guidance from their school supervisor, and the scientists in the field need to be briefed so that support can be provided where they can. If you or your students are interested in undertaking a research project with us, you should contact schoolresearchprojects@opwall.com.

For more information visit the Opwall website - https://www.opwall.com/schools/educational-benefits/independent-research-project/.

Relevance of their expedition to the syllabus

Specific specifications for Biology, Geography and Environmental Studies have been reviewed for over 10 examination boards from around the world to see how relevant a student's expedition experiences will be when related to what they learn in their classroom. The tables in the appendix section show how this matching works although not all topics are relevant to all sites so have been grey-out.

12. Additional Reading

Most of the following are available from: http://www.nhbs.com or http://www.amazon.co.uk

General travel guides:
Lonely Planet Fiji: 7th edition (June 2006)
ISBN: 1741042887

The Rough Guide to Fiji: November 3, 2014
by Rough Guides
ISBN-10: 1409351335

Wildlife:
Fiji's Natural Heritage (Hardcover) May 2002
by Paddy Ryan
ISBN: 0908988141
(Written for the general reader as well as for the natural history enthusiast, Fiji's Natural Heritage is the only book that provides a comprehensive overview of Fiji's rich biodiversity. The Fiji Islands have a large number of endemic species. These and the introduced species are illustrated and described with their common, scientific and Fijian names given.)

A Guide to the Birds of Fiji and Western Polynesia: including American Samoa, Niue, Samoa, Tokelau, Tonga, Tuvalu and Wallis and Futuna.
By: Dick Watling
Paperback | Dec 2004 | Edition: 2 | #150272 | ISBN: 9829030040

Pocket Poster Guide to the Birds of Fiji - Volume 1 – Land birds
By: Dick Watling
Poster | Dec 1999 | #99085

Pocket Poster Guide to the Birds of Fiji - Volume 2 - Sea and Shorebirds
By: Dick Watling
Poster | Dec 1999 | #99087 | ISBN: 9829030024

Reptiles and Amphibians of the Pacific Islands: A Comprehensive Guide
By: George R Zug
Paperback | Jul 2013 | #203590 | ISBN-13: 9780520274969

Palms of the Fiji Islands
By: Dick Watling
Paperback | Dec 2005 | #153678 | ISBN: 9829047024

Flora Vitiensis Nova: a New Flora of Fiji (Spermatophytes Only) - Comprehensive Indices Vol 6
By: Albert C Smith
Hardback | Dec 1996 | #182118 | ISBN: 0915809222

Reef and Shore Fishes of the South Pacific: New Caledonia to Tahiti and the Pitcairn Islands
By: John E Randall
Hardback | Jul 2004 | #144130 | ISBN: 0824826981

Fiji's Wild Beauty - A photographic guide to coral reefs of the South Pacific (Paperback) by Achim Nimmerfroh
Publisher: Nimmerfroh Dive Productions (12/2006)
Language: English
ISBN: 978-3-925919-82-4

Coral Reef Fishes: Indo-Pacific and Caribbean (Paperback) Dec 2001
by Ewald Lieske, Robert George
ISBN: 0691089957

Ecology, Conservation and Culture:
Climate Change in the South Pacific: Impacts and Responses in Australia, New Zealand, and Small Island States – Vol 2
Edited By: Alexander Gillespie and William CG Burns
ISBN 978-0-306-47981-6

Terrestrial Ecoregions of the Indo-Pacific: A Conservation Assessment
By: Eric Wikramanayake, Eric Dinerstein and Colby J Loucks
Series: World Wildlife Fund Conservation Assessment Series
Paperback | Dec 2001 | #122051 | ISBN: 1559639237

The Pacific Islands: Environment and Society
By: Moshe Rapaport
Paperback | Apr 2013 | Edition: 2 | #204506 | ISBN-13: 9780824835866

Biodiversity and Societies in the Pacific Islands
By: Sébastien Larrue (Editor), Arthur Lyon Dahl
Paperback | Apr 2013 | #209145 | ISBN-13: 9782853998772

Prehistory in the Pacific Islands: A Study of Variation in Language, Customs, and Human Biology
By: J Terrell
Paperback | Jun 1988 | #34038 | ISBN: 0521369568

Other:
Marine Life of Fiji & Tonga DVD (Region 2): A Video Identification Guide
By: Josh Jensen and Liz Harlin
DVD | region 2 | Apr 2007 | #166986

13. Appendices

The following tables suggest how specifications for Biology, Geography and Environmental Studies might link with your expedition experience through lectures, practicals or in discussion topics: keywords are used for the matching. Topics which have been greyed-out are unlikely to be relevant at this expedition location.

Table 1: Biology

Topic	Biology	AQA		C	CCEA		C.Int		Ed/Sal		OCR		SQA		WJEC		AP	IB
	Levels: S=AS 2=A2 H =Highers	S	2		S	2	S	2	S	2	S	2	H	AH	S	2		
Evolution, Classification and DNA	Evolution; Speciation; Species; Endemism; Gene pool; Allopatric; Sympatric; Isolation; Variation; Adaptive radiation Adaptation; Wallace; Darwin		◆	◆		◆		◆	◆		◆		◆	◆		◆	◆	◆
	Classification; Taxonomy; Binomial system; Dichotomous Keys	◆		◆	◆			◆	◆	◆	◆			◆	◆			◆
	PCR; Genome sequencing; Genetic fingerprinting; DNA profile		◆	◆	◆					◆		◆	◆			◆	◆	◆
Ecology and Ecosystems	Ecology; Habitat; Niche; Abiotic; Biotic		◆	◆	◆		◆		◆	◆	◆					◆	◆	◆
	Biome; Ecosystems; Rainforests; Deserts; Coral reefs; Mangroves; Marine; Coasts; Hot arid; Semi-arid; Woodland Bush; Tropics; Tropical		◆	◆		◆	◆					◆				◆	◆	◆
	Populations; Competition; Interspecific; Intraspecific; Predator Prey; density dependent; independent: Symbiosis		◆	◆		◆	◆					◆				◆	◆	◆
	Succession; Climax community		◆			◆				◆	◆	◆				◆		◆
	Biodiversity	◆		◆	◆			◆	◆	◆	◆				◆		◆	◆
	Practical work; Field techniques; Ecological sampling; Random sampling; Transects; Capture, mark, release and recapture; Biodiversity indexes; Data handling and; presentation; Quadrats; Statistical testing; Measuring; GIS; Research tools		◆	◆		◆				◆	◆	◆	◆	◆		◆	◆	◆
	Written reports; Research project; Report; Case studies			◆					◆				◆	◆		◆	◆	◆
Agriculture, Human activities, Conservation and Sustainability	Sustainability	◆		◆					◆	◆		◆				◆		
	Agriculture; Agricultural impact; Agricultural exploitation; Cultivation crops; Food production; Sustainable agriculture; Sustainability; Forestry; Timber; Deforestation; Fisheries; Over fishing; Deforestation; Human management; Human effects; Human activities	◆				◆						◆	◆			◆	◆	
	Fair-Trade; Coffee; Rain Forest Alliance; Ecotourism; Tourism; Carbon trading; Greenhouse gas emission control (REDD)															◆		
	Indicator species; Pollution; Climate change; Global warming Carbon footprint; Fossil fuels		◆	◆		◆				◆	◆		◆				◆	◆
	International conservation; Endangered species; Invasive species; Biological control; Pests; CITES; Ethical, Local; Global	◆	◆	◆		◆		◆			◆	◆	◆			◆		◆
	National Parks; Wildlife reserves							◆										◆
	Environment; Environmental monitoring; Environmental impact; SSSI																	
Behaviour	Animal behaviour; Primate Social behaviour; Courtship; Territory; Co-operative hunting; Herbivores; Grazing	◆		◆	◆			◆				◆	◆	◆		◆	◆	◆

Table 2: Geography and Environmental Science

Topic	Environmental Science APES and ESS	IB ESS	APES	UK Geography A Levels AQA, Edexcel, eduqas and OCR

Evolution, Classification and DNA	Evolution; Speciation; Species; Endemism; Gene pool; Allopatric; Sympatric; Isolation; Variation; Adaptive radiation Adaptation; Wallace; Darwin	◆		There has been a complete revision of UK Geography A levels which are to be first examined in 2017. Although our expeditions are possibly not going to be as relevant to Geographers as they are to Biologists there are a significant number of topics covered by the various examination boards in which matching occurs with reference to: • human impact on ecosystems • ecosystems in general • biodiversity • sustainability • fair trade • work of NGOs • deforestation • GIS • carbon trading • climate change • case studies linked to biomes such as rainforests. All exam boards expect experience of field investigation techniques, statistical use and data manipulation which are very relevant to their experiences whilst on location at their expedition site. Almost all boards now require an independent investigation by students which fits really well with the present IRPs although the topic chosen must relate to their exam syllabus so topics such as the REDD scheme are possible choices. Their IRPs are between 3,000 and 4,000 words and should take up 4 days minimum to achieve. AQA have defined primary data as "Primary data is defined as unmanipulated data, either collected in the field or a raw dataset. " which will work well with past data sets and the research data they help to collect when on their expedition. Specific detailed exam board matching is available on request.
	Classification; Taxonomy; Binomial system; Dichotomous Keys			
	PCR; Genome sequencing; Genetic fingerprinting; DNA profile			
Ecology and Ecosystems	Ecology; Habitat; Niche; Abiotic; Biotic	◆	◆	
	Biome; Ecosystems; Rainforests; Deserts; Coral reefs; Mangroves; Marine; Coasts; Hot arid; Semi-arid; Woodland Bush; Tropics; Tropical	◆	◆	
	Populations; Competition; Interspecific; Intraspecific; Predator Prey; density dependent; independent: Symbiosis	◆	◆	
	Succession; Climax community	◆		
	Biodiversity	◆	◆	
	Practical work; Field techniques; Ecological sampling; Random sampling; Transects; Capture, mark, release and recapture; Biodiversity indexes; Data handling and; presentation; Quadrats; Statistical testing; Measuring; GIS; Research tools	◆	◆	
	Written reports; Research project; Report; Case studies	◆	◆	
Agriculture, Human activities, Conservation and Sustainability	Sustainability	◆	◆	
	Agriculture; Agricultural impact; Agricultural exploitation; Cultivation crops; Food production; Sustainable agriculture; Sustainability; Forestry; Timber; Deforestation; Fisheries; Over fishing; Deforestation; Human management; Human effects; Human activities	◆	◆	
	Fair-Trade; Coffee; Rain Forest Alliance; Ecotourism; Tourism; Carbon trading; Greenhouse gas emission control (REDD)	◆		
	Indicator species; Pollution; Climate change; Global warming Carbon footprint; Fossil fuels	◆	◆	
	International conservation; Endangered species; Invasive species; Biological control; Pests; CITES; Ethical, Local; Global	◆		
	National Parks; Wildlife reserves			
	Environment; Environmental monitoring; Environmental impact; SSSI	◆		
Behaviour	Animal behaviour; Primate Social behaviour; Courtship; Territory; Co-operative hunting; Herbivores; Grazing			