Department of Defense
Legacy Resource Management Program

PROJECT 09-345

Automated bird and amphibian species identification computer program

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Draft of Expected Products

1. We will collect and process approximately 500,000 1 minute recordings
2. We will improve the species identification algorithms.
3. We will provide onsite workshops for managers and have a fulltime technician dedicated to working with them
4. Final report on the results from the three installations
5. The Fact Sheet is a required product for all Legacy projects. (Attached- separate file)

Collect and process approximately 500,000 1 minute recordings

The major goal of this project was to establish biodiversity monitoring stations to collect audio recordings in three DOD installations. The three installations were: Schofield Barracks-Oahu, Hawaii, Pohakuloa Training Area-Hawaii, Hawaii, and Ft. Huachuca, Arizona. In the first year of this three year project, we established two test stations in Puerto Rico. The monitoring stations at the three installations were established in the second year and upgraded and maintained during the third year. Seven permanent stations are still transmitting data (Puerto Rico-2, Arizona-1, Schofield Barracks-1, and PTA-3). All recordings from all sites are permanently stored and are available at the project website (97).

Sabana Seca and El Verde, Puerto Rico

The first two biodiversity monitoring stations were established in Puerto Rico as test sites before moving to the DOD installations. The first monitoring station was established in Sabana Seca, Puerto Rico, in an herbaceous wetland where a new species of *Eleutherodactylus* (coqui frog) was described. The second station was located at the El Verde Field Station, the site of the Luquillo NSF-Long Term Ecological Research site. To date we have collected 97,446 1-minute recordings from Sabana Seca and 74,641 from El Verde. Both stations are still running, and we have had few problems with these stations.

Schofield Barracks-Oahu, Hawaii

At Schofield Barracks on Oahu, Hawaii we established two permanent recording stations: Kaala and Koolau. To date we have collected 2,151 1-minute recordings from the Kaala station and 41,973 from the Koolau station. There are two main reasons for the low number of recording at this installation. The first reason is that, as at all installations, we were not able to use the military connection to the internet. In all cases we had to find alternative access, and in the case of Schofield Barracks this took a long time, and delayed the establishment of the monitoring stations. In the end, our collaborators in the office of natural resource established an independent internet connection. The second problem was interference from the FAA radar station located on the top of Mt. Kaala. Much effort went in to the Kaala station; we visited this site eight times. As seen in Figure 1, the radar produces a pulse of energy every 11 seconds. We developed filters to eliminate this “noise” from the recordings, but the radar negatively affected other components of the monitoring station,

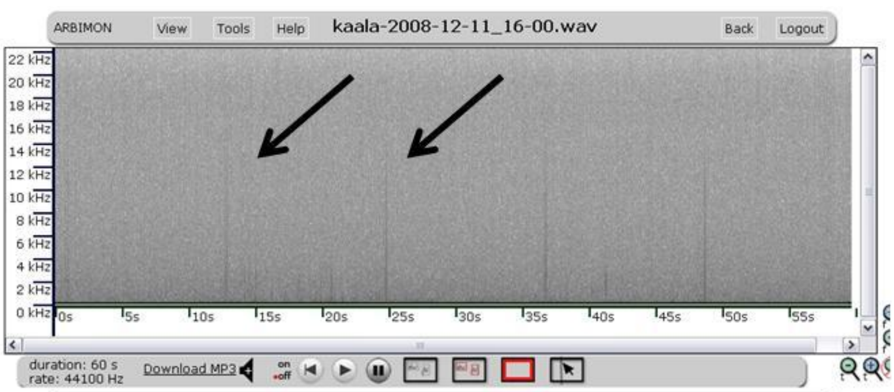

Figure 1. A 1- minute recording from the Mt. Kaala monitoring station, showing the interference from the FAA radar.

particularly the computer and the radio antenna. These components were replaced twice, but when we returned in December 2010, the computer and radio were not working, so we dismantled the Kaala station. The Koolau station was established on November 23, 2009, and is still functioning without any additional maintenance. The site is approximately 10 miles from the base station, and although the internet connection is not strong because of interference with vegetation, we still have been receiving recordings.

In addition to the permanent recording stations, we provided the resource managers with four portable recorders. Four people were trained in the use of the portable recorders, and Krista Winger was given a detailed orientation in how to troubleshoot the iPod touch recorders, and how to download the recordings to a local computer and then upload them to the project website.

Pohakuloa Training Area- Big Island, Hawaii

At Pohakuloa Training Area- Big Island, Hawaii we established three permanent recording stations: PTA-1, PTA-2 and PTA-3. To date we have collected 75,316 1-minute recordings from the three stations. Presently, all three stations are functioning. There are two main reasons for the low number of recording at this installation. The first is the long distance and rough road between the field sites and offices. These stations are approximately 27 miles from the base station at the Hawaiian Preparatory Academy (HPA) in Waimea, and occasionally the radio loses connection. This could be solved by disconnecting and reconnecting the antenna, but the travel time for the collaborators is >2 hours on a very rough road. The other problem that we have had at this site is the computers turning off. This has been a problem with PTA #2 and PTA #3. We have tested and changed all the components, but this problem has continued. In December, we replaced all computers with iPod Touch. To date all stations are functioning, but the quality of the recordings are not ideal. We have designed a new pre-amplifier and we will be sending these to our collaborators in PTA.

In addition, to the three permanent recording stations, we have established three real-time camera traps on a past breeding ground of the Nene (Hawaiian goose).

Ft. Huachuca, Arizona

At Ft. Huachuca, Arizona we established two permanent recording stations: Station #1 (high elevation) and Station #2 (Garden Canyon). To date we have collected 2,937 1-minute recordings from Station #1 and 19,682 from Station #2. There are four main reasons for the low number of recording at this installation. The first two problems are related to wildlife: bears and rodents. Soon after we established the stations we lost the connection to station 1. Weeks later, when our local collaborator Sheridan Stone was able to return to the site, he determined that the station had been attacked by a bear and many of the cables had been cut. Sheridan reinforced the structure, but we had to make an unplanned trip to rewire the station. Within months, we lost connection to both stations. This time it was due to rodents chewing audio and Ethernet cables. All cables are now placed within a heavy conduit. The third problem was associated with the base station at the Cochise Community College. The building where the radio antenna and computer are housed was remodeled, and during this process the computer was flooded and the Ethernet cable from the antenna was cut. These problems have all been resolved. The most difficult problem has been communication interference. Although both stations have line of site to the base station antenna, the connection is not strong. Our installation collaborator believes that the problem could be arising from activities on the base. For example, Ft. Huachuca houses the Army's Electronic Proving Ground and a radar-equipped aerostat of the Drug Enforcement Administration, which is located near Garden Canyon. We believe that interference from these activities frequently interrupts the transmission of our files. Given these problems, in October 2010 we decide to dismantle Station #1 because this site was again attacked by a bear and it has the poorest transmission quality. We spent a day testing other sites around the base, but all sites had problems of interference, so no new monitoring site was established.

In addition to the audio recordings, these two permanent recording stations include camera traps. Two people were trained in the use of the portable recorders, and wildlife biologist Betty Phillips was given a detailed orientation in how to troubleshoot the iPod touch recorders, and how to download the recordings to a local computer and then upload them to the project website.

Improve the species identification algorithms

To improve the species identification algorithms, we first needed to make improvements in the hardware and some of the software components.

Hardware - During the third year of the project we have made major changes to both the permanent and portable biodiversity monitoring stations. Specifically, many improvements were made to the permanent stations, including the incorporation of real-time camera traps and we have developed a new version of the portable stations.

Improvements and redesign of the permanent stations

1. A microcontroller was installed in the netbook computer, so that the computer starts automatically when power returns. Previously, someone had to go to the site to physically press the power button.
2. We changed the antenna/radio system for wireless communication to a system that allows web access to monitor the signal strength and data transfer.
3. Real time camera traps can be incorporated into the monitoring system. This was done by incorporating a microcontroller in a standard camera trap, and this allows us to send photos instantly through a USB cable connected to the netbook computer and on to the web site for almost real time results.
4. In an attempt to have a uniform recording system, in some permanent stations, we have replaced the netbook computer with Apple's iPod Touch (the same system we use in the portable recorders) and a wireless access point. This change reduces the cost of the system, reduces the size, and reduces energy demand by 57%.
5. In the stations with a wireless access point, the microcontroller for the camera traps was redesigned and an SD card with integrated Wi-Fi was installed to allow the camera to send photos through a wireless network to the base station. These cameras traps can now be placed further away from the radio/antenna because they are not limited by the USB cable. These cameras have their own independent solar system.
6. We are presently trying to make a similar modification to a commercial weather station so that we can transfer data in real time directly to the project webpage.

Portable recorder station.

1. A printed circuit board was designed to provide energy for the iPod touch as well as to serve as an in-line pre-amplifier for the microphone.
2. Currently this board is been redesign to reduce the effect of high humidity and to reduce electrical noise in the recordings.

Software - In terms of software development, during the last year most of our effort was dedicated to the migration to a new programming platform and redesigning the project database.

ARBIMON Web Application - As was reported last year, due to cross browser conflicts especially with Internet Explorer, we made the decision to redevelop all existing interactive tools as well as any new tools in a new web application programmed with a Flash framework called OpenLaszlo. This task proved to be more difficult that we expected, and rather than taking six months as we had expected it took 12 months. All components are presently being tested. Below, we describe the four main modules.

Project manager – This module allows a new user to create their project. The manager can assign site names, location, time zone, and species, as well as add other users with their appropriated privilege level.

Recordings Uploader – This module is used to upload recordings from the portable "iPod touch" stations and it initiates the processing of the recordings.

Visualizer – This module is used for viewing, listening, and annotating recording. Of all the modules, the visualizer was the most developed, and developing a new version in OpenLaszlo has been a challenge, but it is important that we have tools that function across all browser platforms. The interface of the tool was completely redesigned and plus the code had to be rewritten to insure compatible with the new database. In addition, many new features were added including functions for: song classification, species validation, adding species to projects, resizing the spectrogram window, and amplifying audio.

Species identification module - The species identification module is the latest component that we have added to the ARBIMON web application. There are at least 11 steps for producing a species identification algorithm. They include: creating training data by opening recordings, associating ROI boxes into a call, annotate the species name, call type and the order of the boxes (i.e. notes or syllables), select the appropriate model, determine the probabilities for the initial transition matrix, use the training data to create a model, apply the model to recordings, define call filters, evaluate the results of the model, add the correct responses to the existing training data, recalculate the model with the new training data, and apply the model again. This iterative process should continue until the model has obtained a high level of accuracy. The module that we have developed accomplishes every aspect of this process. Furthermore, much effort has gone into producing a user interface that is intuitive and user friendly. During the last few months, biologist have been using the system and interacting with the programmers to fix program bugs and to make modification to the graphic interface.

To help standardize the level of accuracy among the different species identification algorithms we are developing an interface that will show how the level of accuracy (true positives) changes as the training data increases.

Once an algorithm has reached an acceptable level of overall accuracy the user will be able to submit it to the approved species identification algorithm table with the metadata associated with the algorithm: the number and source of the training data, a description of the model, and the overall accuracy of the algorithm.

Onsite workshops for managers

In October 2010, we spent two days with Sheridan Stone and Betty Phillips. We also meet independently with the collaborators from Cochise Community College Carlos Cartagena and Gilbert Parra. In our meeting, with the resource managers of Ft. Huachuca we covered three topics: 1) communication interference, 2) use of portable records, and 3) base specific natural resource priorities. In terms of the communication interference, we decided that the next step should be for Sheridan Stone to contact a representative of the Army's Electronic Proving Ground to determine if there are areas and frequencies that we could use that would not conflict with base activities. Second, we demonstrate the use of the portable records that could help them with specific projects (e.g. invasion of exotic frogs or spotted owl surveys). The demonstration included a laboratory and field component. Last we discussed the base specific needs for biodiversity monitoring. A potential new project would be to monitor bat activity given the concern of the white-noise syndrome. Many of the bat caves are very isolated; therefore, if there is no interference we could potential collect and send data in real-time from up to 26 miles (the distance in Hawaii) between the sampling point and the base station. They were also interested in expanding the use of the portable recorders. These could be used to monitor intermittent ponds or spotted owl populations.

In December, we meet separately with the Schofield Barracks and Pohakuloa Training Area groups. In both cases, the main topics of the workshop were a summary of accomplishments and challenges of the last two years, and a discussion with both groups about their future monitoring needs. Again, as in Ft. Huachuca, there is interest in bats. To this end, we have begun to develop a bat detection system that will work in parallel with the present audio recording system, and different from other bat detection systems, we are trying to develop a system that will send the recordings to the project website in real-time. The Schofield Barracks group also encouraged us to produce a webcam that could send photographs in real-time to monitor flowering and fruit/seed production. This could greatly reduce the monitoring costs of endangered populations in isolate sites. In Schofield Barracks, we also dedicated time to review the processes for using the portable recorders.

Final report on the results from the three installations and workshop

At the end of the funding period (December 2010), we have seven functioning recording stations and more than 300,000 1-minute recordings. In addition, we have made major advances in the hardware and software design related to this project.

In terms of hardware development, the major accomplishment during the last year was a new design of the permanent stations that allowed us to replace the netbook computer with and iPod Touch. This has two important effects: 1) we are now using the same recording device for the portable and permanent stations, and 2) by using the iPod Touch we have reduced energy consumption by approximately 57%.

In terms of software, we have numerous changes to the species identification component. In the laboratory, we have had biologist working closely with the programmers to help identify programming bugs and to make the steps as intuitive as possible for the user. Although we have successfully used the species identification module for frog species in Puerto Rico, we have only tested the system with a few bird species from Hawaii. We created a model for the Japanese bush warbler, and this showed that in the Koolau site (Oahu, Hawaii) there was a peak in calling in December and January.

In addition, to identifying individual species, we have also developed analytical tools to evaluate the soundscape, the combination of physical, biotic and anthropogenic sounds. These analyses have many potential uses including rapid biodiversity assessments or monitoring the impact of anthropogenic noise (e.g. traffic noise). To test these methods we calculated the acoustic diversity for three tropical communities based on 26,397 1-minute acoustic files recorded between April and May 2009, 2010. In this analysis we compared the soundscape of a tropical forest in La Selva, Costa Rica, with a tropical forest (El Verde), and a wetland (Saban Seca) in Puerto Rico (Figure 2). The results showed a dramatic difference among the sites, but also differences within a site depending on the year or the hour. Sabana Seca and El Verde both have a large amphibian population and this is reflected in a peak of activity around 9 pm.