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EDUCATION

Participatory Ecological Monitoring and Environmental Education in 2011

Written by Troy D. Abel

In the summer of 2011, faculty from Western Washington University's (WWU) Huxley College of the Environment implemented a five week field course in Costa Rica exploring Participatory Ecological Monitoring and the pedagogies of Environmental Education. Faculty and students completed observational studies of tree diversity, soil composition, avian bioacoustics, collaborative conservation management, and environmental education. Comparative observations were conducted at biological stations in Carara and Corcovado National Park in collaboration with Park staff. We hypothesized that significant contrasts will occur between Carara's secondary and Corcovado's primary forests and their neighboring communities. Our results inform Costa Rican conservation and management strategies as well as contribute to the growing field of participatory ecological monitoring. Biodiversity conservation begins inside of Costa Rica's and other nation's protected areas but will be complemented by research, education and outreach in the communities outside National Parks.

Study Sites

Our two field sites were located in Carara and Corcovado National Parks and encompassed ten days of fieldwork at the Quebrada Bonita and Sirena biological stations. Students in our program conducted field studies and evaluated management policy between the ecosystems of a transitional smaller transitional forest (Carara) and a larger tropical wet forest (Corcovado). Data was collected in a gradient of habitats representing relatively pristine to highly disturbed conditions. Individual research activities were united by a common focus on the science and implementation of effective environmental monitoring. Specifically, students worked in one of five complementary research areas: (1) digital recording and analysis of bird species assemblages; (2) observational analysis of soil composition and quality around trails; (3) observational analysis of tree diversity and abundance; (4) observational assessments of participatory conservation policies; and (5) observational assessments of environmental education pedagogies. Students benefited by participating in this conservation-oriented research while park staff and visitors also gained from an increased knowledge of the park's flora and fauna.

Student groups were based near each study site for eight days. The Carara visit began on June 23 and ended July 1 while students lodged in Corcovado's Sirena biological station from July 9 to July 17. Our observational methods required no physical specimen collections; only digitized recordings, photographs, and data notations.

Curating of Material

No collections were made thus no material curating was necessary. No collections were made thus no justification was developed. Our observational methods caused only slight disturbance to soil and vegetation. We observed in small areas (0.01 ha) for several hours, and so the leaf litter and vegetation of that small area was disturbed slightly. Generally, effects of this kind of observa-

Photo credit .... Kelley Palmer-McCarty

tions are not noticeable a few days after collection. We believe our observational methods had negligible affects to both flora and fauna in these areas.

Avian Field Work

Ashley Allan, Neddy Dondup, Tanika Ladd, and Kelley Palmer-McCarty composed the 2011 avian team which compared bird species richness and abundance in Carara versus Corcovado. They tested the null hypothesis that there will be no difference in species richness or abundance between the Carara and Corcovado sites. Birds are convenient subjects because they are fairly well documented in Costa Rica (Janzen 1983, Stiles and Skutch 1990) and because they are often sensitive to environmental degradation (Morrison 1986, Lambeck 1997, Veneir and Pearce 2004). These taxa certainly do not represent the entire biota, but they are convenient for illustrating variation in environmental conditions and they can be documented consistently by non-professional field observers. Many species of birds also are recognized as important ecological attributes in their own right.

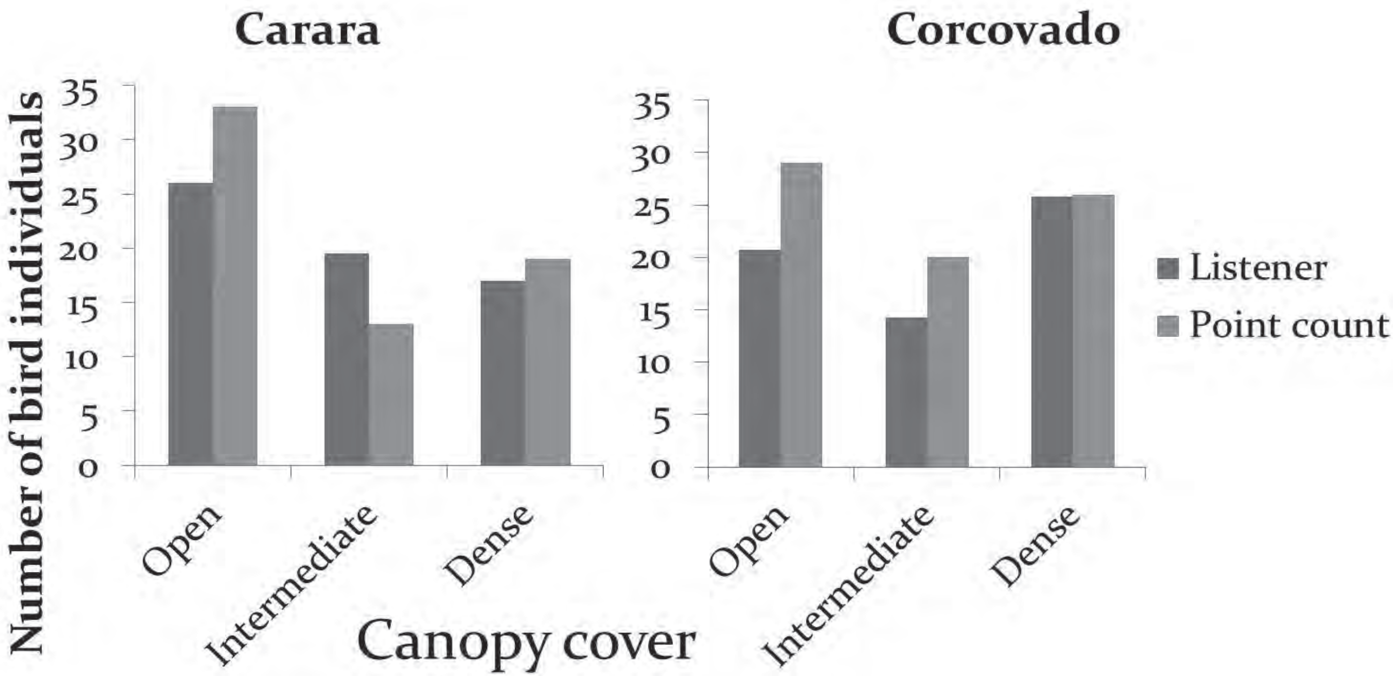
Systematic monitoring of bird and mammal populations is a challenging task that has traditionally required high levels of skill by trained field observers. Undergraduate participants were not expected to possess or acquire these skills. Instead, and following Hobson et al. (2002) and Rempel et al. (2005), we employed acoustic recordings to help document species assemblages in the Costa Rica study areas for two reasons. First we wanted to provide a meaningful field experience for the students during the limited time available and, second, we aimed to explore field methods that are not dependent on highly skilled field observers, which might be difficult to enlist continuously in a long-term biological monitoring program. A method for obtaining reliable data with the help of non-experts is more likely to be sustained by conservation managers on a long-term basis.

Avian methods

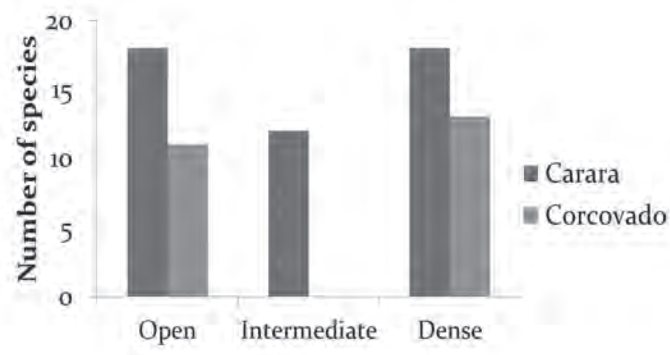
Measuring and quantifying the diversity of avifauna in tropical jungles can be a difficult task that is confounded by dense vegetation and bird species that look nearly identical to others. Bioacoustic monitoring is a method for quantifying birds by using sensitive microphones to record bird sounds. A Compression Zone Microphone (CZM) from Riverforks.com seen below was utilized with a Marantz Professional Portable Recorder, Model PMO690 mounted on a camera tripod. Simultaneous four person point counts and ten minute recordings were collected in open, intermediate, and dense canopy cover determined with a densitometer. Local guides from each park helped count different birds based on recorded calls.

Recording results

The highest abundance of 33 observed birds and 25 recorded individuals was found at the low canopy density site at Carara. Five fewer individuals were found in Corcovado's open density site with 29 observed and 20



Carara
Corcovado
Number of bird individuals
35
30
25
20
15
10
5
0
Open
Intermediate
Dense
Canopy cover
Listener
Point count



identified in recordings. Bird abundance declined in the intermediate sites in both parks, with only 13 observed at Carara, 20 seen in Corcovado, 20 identified in the Carara recording, and 14 heard in Corcovado's recording. Dense canopy cover produced a few more birds than intermediate with Carara registering 19 birds observed and 17 identified from recordings. 26 were both observed and recorded in Corcovado's dense canopy site. The figure above displays these differences.

Overall, Carara only exceeded Corcovado bird abundance in the open density site and on average, the student team found more birds in the bigger park. Conversely, when local guides with birding experience counted the number of unique species recorded at each site, Carara registered higher diversity than Corcovado. 18 species were identified in Carara's open and dense canopy recordings compared to only eleven and thirteen respectively in Corcovado. An intermediate canopy density recording comparison was not completed due to the lack of the experienced birding guides availability.

Avian Discussion

Through the lens of island biogeography, Carara's avian species richness was unexpectedly greater than Corcovado's. Students concluded that Carara's transitional forest types probably explained the greater diversity as bird species from the Mesoamerican and Amazonian ecosystems overlap here. Moreover, Carara's small size should not necessarily be used as justification to direct conservation resources to other and larger parks. The 2011 team recommended that future studies should combine point and recorded counts with an experienced local birding guide to identify species richness. Also, they suggested that future point counts be combined with botany plots to allow comparisons of avian abundance with tree diversity.

Forest Transects

Our botany group of students included Danny Goertz, Kellianne Lane, Reed McIntyre, and Katie McNett who inventoried the contrasting tree diversity in the two parks. Biological complexity and species richness are the hallmarks of lowland neotropical rainforests (Forsyth and Miyata, 1984; Kricher, 1999; and Terborgh 1992) and exposed these students to biodiversity unmatched by any

Photo credit .... Kelley Palmer-McCarty other ecosystem. Though generally high, species richness exhibits variability. For instance, Knight (1975) found more tree species in the mature forest of Barro Colorado Island, Panama than in a younger forest, 151 in the former versus 115 in the latter. Likewise, Lieberman et al. (1996) found species composition varying by altitude in Costa Rica's La Selva reserve. Therefore, the 2011 botany team's null hypothesis was that no difference in forest structure and composition would be discernible between the two park sites. Their alternative and primary hypothesis was that Corcovado's forest will be more diverse than Carara's. Moreover, they expected that there would be fewer trees in the 10—50 cm diameter at breast height (dbh) range and more in the >50 cm class in 1992).

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Transect Methods

Following one set of methods commonly used in Dr. David Wallin's Forest Ecology class (ESCI 407), students constructed two forest inventory plots by nesting circular plots within the bounds of two concentric circles, the inner circle having a projected area of 0.1 ha and the outer circle having a projected area of 0.2 ha (1 ha = 10,000 m2). On level terrain, the smaller inner circle will have a radius of 17.8m and the larger outer circle will have a radius of 25.2m. To lay out each plot, students used a compass and 30m tape to flag eight points, 90 degrees apart at distances of 17.8 and 25.2m from the plot center.

Students first calculate canopy height with tape measure and a clinometer. Second, all small trees between 10 and 50 centimeters in diameter are measured within the inner circle (diameter = 17.8 m). For large trees, students measured the width of all trees over 50 cm in the circular plot (diameter = 25.2 m) because they are less abundant and require a larger sampling area to ensure more representative measurements.

Tree species identification was led by biologist and guide Alberto Herrerra who walked students through an identification key developed for Costa Rican forests as seen here. Students first identify a tree's family by examining the color of the sap that takes them through the key's first branch, then leaf structure, stipule presence, and then leaf

Tree Identification Key

texture as the second, third, and fourth respective branches. Often, leaves from large trees are not readily apparent on the ground, so a spotting scope is used to help with leaf classification (see photo below). After the family is determined, an additional identification book is used to key the species.

Transect Results

Thirty-six individual trees and 24 species were identified in the Carara secondary forest with half (18) falling between 10 and 20cm. The Corcovado plot had 43 individuals and 30 species. As expected, more trees and more species were inventoried in the Corcovado transect with more in the 20-30 and > 40cm classes. Carara also had a lower Shannon-Wiener diversity index than Corcovado; 1.337 compared to 1.563 respectively. The composition of the two forests were also stark; only 7 with only 7 species found in each. The results indicate that the primary forests of Corcovado are more structurally and biologically diverse due to ecological succession, conservation practices and geography of the park.

Photo credit .... Alberto Herrara

Soil Tracts

Sean Cooper, Katlynne Schaumberg, Scotty Seren, and Alexander Smalldon made up our 2011 soil team who contrasted erosion from trails at both study sites with the mentoring of Dr. Andy Bach. Strategies for the sustainable development of tropical rainforest environments frequently promote ecotourism and small-scale extractive activities as having important economic benefits and only minimal environmental impacts. Trail-dependent forest activities, however, risk accelerating soil erosion and degrading aquatic environments with eroded sediments (Wallin and Harden, 1996). Water runoff from trails in exasperated by increased slope, increased trail length, and by soil compaction. All three variables can be easily measured by non-damaging methods, then statistically related to examine the potential for better trail design, as well as relating erosion to existing erosion control devices such as stairs, gravel cover, and other surface covers. Through qualitative observations and quantitative measurements the soils team assessed the importance of trails to surface storm flow and soil erosion in tropical rainforests, where trail

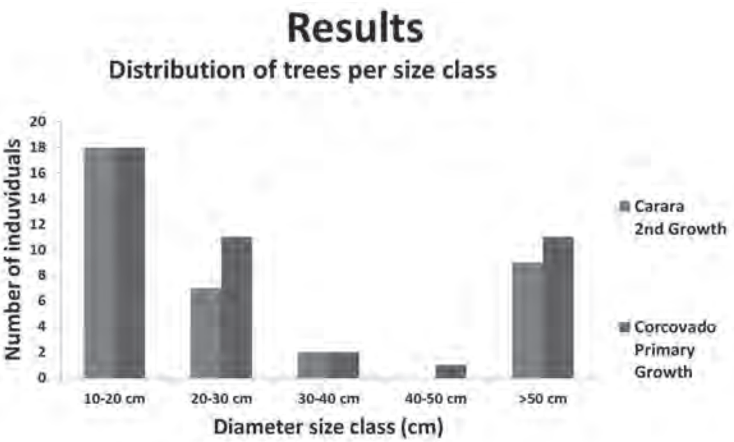


Photo credit .... Andy Bach

Carara Soil Pit

erosion might degrade ecotourism trails and negatively affect the terrestrial and aquatic habitats the trails otherwise help to support.

In selecting sites in Carara and Corcovado, students injected some randomness into their sampling by walking down a trail approximately one forth of a kilometer and choosing the middle of the sample site to be a tree at the side of the trail. The soils team collected data from both flat and sloped sites at both parks, so the only consideration in secion selection was to satisfy this component. The site was then logged on the GPS and a picture was taken for the record. After choosing a site observers then marked off a three-meter long trail site using a measuring tape with the tree in the middle. Twenty random measurements were taken along the trail length, while twenty more were recorded at a distance of three meters perpendicular from the trail. Students then assessed a trails visual appearance for signs of erosion using a trail condition class method explained in Mark C. Jewell and William E. Hammitt's study (2000), "Assessing Soil Erosion on Trails: A Comparison of Techniques." Following their evaluation, researchers rated each trail from Class 0-5, with class O being a trail that is barely distinguishable while a Class 5 entails obvious soil erosion with exposed roots, rocks and or gullying.

Students measured slope with a clinometer, length with a tape measure, and compaction with a pocket penetrometer. The pocket penetrometer is less damaging to the soil surface than pushing a nail vertically into the soil surface. These measurements can be related to visible evidence of erosion downslope and trail characteristics such as width, depth, root exposure and other impacts.

Horizon (Depth)	Description
O (Leaf Litter)	1-2 leaves thick
A (0-14cm)	Granular structure Few stones <5%. Roots-larger ones concentrated near surface. Many fine roots. Color 7.5 YR 3/2 = Dark Brown
AB (14-42cm)	Weak angular blocky structure. Few stones <5%. Roots-less roots than in A horizon, fine roots, very few large roots. Color 10 YR ¾ = Dark Yellowish Brown
B1 (42-65cm)	No obvious structure. Stones 10-20%. Roots-very few roots, only fine roots.
B2 (63-72cm)	No obvious structure. Stones 25%. Very few roots- fine roots. Color 10YR 4/4 Dark Yellowish Brown
B3 (72-101cm)	No obvious structure. Stones 50%. Very few roots- fine roots. Color 7.5 YR 4/6 Strong Brown. (AGE=~thousand to tens of thousands years old) Abundant Mn staining on stone surfaces- Related to fluctuating ground H2O.

In order to gain a better understanding of Costa Rica's soil, students also undertook two side projects. The first project was digging a soil pit in Carara to evaluate tropical soil horizons and their contents. The pit was approximately one meter by two meters and was dug until ground water was reached at 101 cm. After digging the pit, horizons were labeled using a Munsell Soil Color Chart, which involved matching color swatches on the chart to the color of soil in each of the horizons. Then a qualitative analysis was completed where students looked at structure and the presence of roots and or rocks. The second project included collecting pH data from the botany team's plot in both Carara and Corcovado. A pH meter was planted on the north and south side of each tree in the botany plot, left to sit for three minutes, and the average was then recorded.

Soil Tract Results

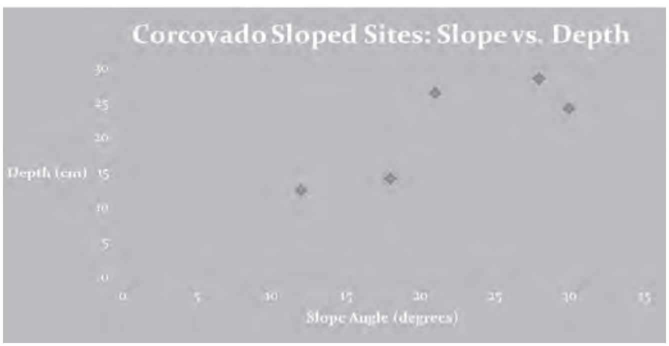
As shown in the two graphs here, the off-trail compaction measurements between Carara and Corcovado were very similar; 1 and 0.75 kg/cm2 respectively. However, when comparing on trail compaction Carara's trails are clearly more compacted than Corcovado's. The significantly greater population of visitors that hike Carara's trails can explain this difference in compaction level. The soil team hypothesized that there would be: (1) a difference between soil erosion; (2) a positive correlation between trail depth and trail slope; and (3) a negative correlation between trail width and trail depth. Data from both sites supported the second hypothesis and the Corcovado results appear on the next page. The data was too inconclusive to support the third hypothesis. Also, pH measurements differed between the two sites.

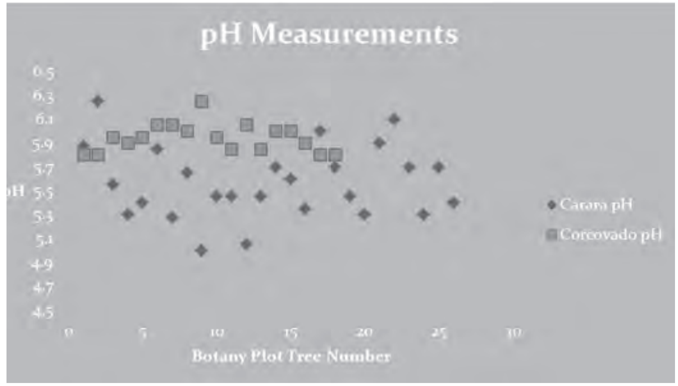
The results from our Trail Condition Class method analysis were almost unanimous throughout both Carara and Corcovado Park. Every site was a Class 5 in Corcovado meaning roots and rocks were exposed, while there were only two fours with the rest Class 5 in Carara. Unfortunately, Class 5's not only indicate a significant amount of soil erosion that can harm aquatic life, but also means bare roots are exposed leaving trees vulnerable. Roots act as lifelines for nutrients as well as an anchor for support and bare roots quickly become damaged by hikers stepping on them to avoid muddy conditions putting the trees themselves in jeopardy.

The pH of the Corcovado botany plot was higher on average than Carara's plot. The average was 5.95 pH in

Corcovado while Carara's average was 5.55 pH. There is a lot more rain in Corcovado and in the 2011 trip, an exceptional amount of precipitation occurred within the few days prior to testing which could explain the more alkaline soil character. Conversely, Carara's rainforest used to be a coffee plantation within the last century and this could partly explain the more acidic soil found in the Central Pacific site.

From the data the soils team collected as well as the qualitative observations made while walking the trails and examining the soil pit, it is clear that trail system erosion in Costa Rican National Parks is an issue that needs further consideration, research, and mitigation efforts. The soil team results were similar to other research. Thomas R. Wallin and Carol P. Harden (1996) found that, "at La Selva, runoff coefficients for trail sites were, on average, more than 40 times greater than those for off-trail sites." They concluded that compaction appears to be the main culprit. "Compaction due to trail use, as evidenced by higher on-trail bulk densities, appears to play a major role in increasing runoff from trail surfaces at La Selva" they said. In conclusion, although Costa Rica has a delicate soil environment that is vulnerable to erosion caused by high rainfall and high visitation rates, with proper assessment and management strategies, trail degradation can be limited by targeting problem areas and Costa Rica's beautiful forest ecosystems can be preserved.





Experiential Education

The fourth group of students explored the pedagogy of environmental service-learning and its impacts on learners. Participants in 2011 included Sara Allen, Pat Chappelle, Dana Christenson, Patrick Connors, and Rachel Youngberg. Their work built upon the 2010 environmental education team made up of Zane Beall, Connor Harron, Lisa Karsen, and Andrea Magnuson. Extensive research has found that learners participating in service-learning not only improve their sense of efficacy or perceived ability to make a difference (Cone 2009; Moely et al. 2002; Simons and Cleary 2006), but service-learners are also more likely to become civically engaged (Billig 2000; Gallini and Moely 2003). Finally, the rare study of environmental service-learning found better critical thinking performance among high school seniors treated with service-learning versus a control group (Ernst and Monroe 2004).

However, research also finds that learner impacts can vary

Photo credit .... Connor Harron

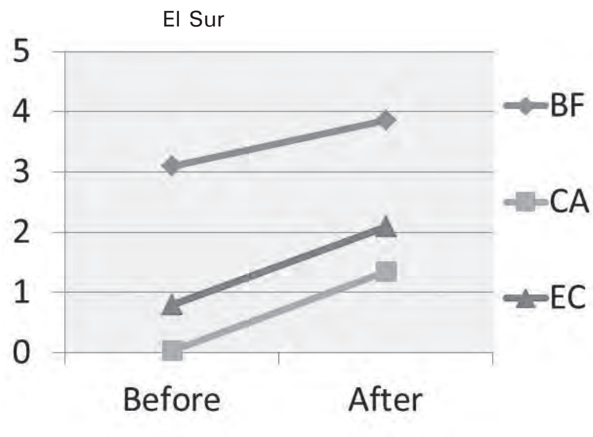
significantly across service-learning pedagogies and serve to reinforce the assumptions that students initially brought with them into the program. (Boyle- Baise & Sleeter, 2000; Dutton & Heaphy, 2003; King, 2004; Maher, 2003; Miller & Stiver, 1997). Our education teams explored how variations in not only the pedagogies, but in different communities may influence learner outcomes.

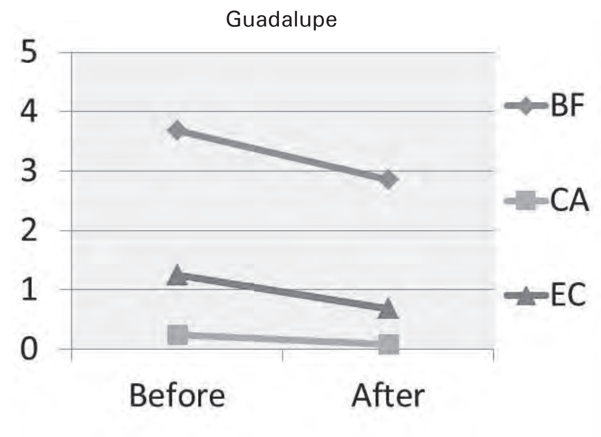
In 2010, students developed and delivered an experiential and experimental environmental education program that focused on trees and their ecosystem services towards bird habitat. Materials include two clear plastic containers, soil, coffee filter, two clear plastic catchments, and tree saplings. Educators then supervised a learner comparison of water filtration between a soil filed bottle versus a similar bottle but with the addition of a coffee filter. Trees and their roots were described as functioning like the filter. Student educators also conducted a pre-assessment by asking learners to draw trees and their role in the environment. A formative assessment included requests for learners to share their observations from the experiment. A post assessment involved learners drawing trees as educators look for images representing clearer biological, emotional, and conservation connections.

In the 2011 iterations, students adopted an avian education program from Cornell University's Lab of Ornithology called Bird Sleuth, or Detectives de Pájaros in Spanish.

Educational results

Two different communities and their school children participated in our curriculum; El Sur near Carara and Guadalupe near Corcovado. Both are rural agricultural communities with a prominent lodge in the town that provides benefits from ecotourism for many residents. However, a major pedagogical variation arose between the two towns because trees to plant were available for a service project in El Sur but not in Guadalupe. The 2010 El Sur group was slightly smaller with nine students ranging in





age from 7 to 11 compared to the 12 students from 5—13 participating from the Guadalupe community. Moreover, the El Sur activities were more structured in both years because students were still in school. When we arrived for our service-learning in Guadalupe, students were on a short break. Similar to the other projects, our students hypothesized that no differences would be observable in the contrast between the Carara and Corcovado student outcomes. But in both years, our students observed more movement between the pre and post-test results in El Sur across three categories; biological representations, conservation actions, and emotional referents.

Unexpectedly, the post-tests for Guadalupe dropped in all three categories assessed in student drawings. Students offered several speculations about the trends. First, the absence of a structured learning experience in Guadalupe struck both students groups in 2010 and 2011 as a major factor. Second, our students also attributed a lot of influence to the presence of trusted and authoritative community member in El Sur. Third, students found that the starkest contrast between the two groups was the variation in the students' depiction of human action. Student drawings from the tree planting group had twice as many examples of conservation action than the other group in the 2010 post assessment. Our students cautiously concluded that the tree planting component was a major factor in the observed differences and demonstrated the influence of environmental service learning.

The 2011 Student participants appear below with the El Sur students and teacher. In the first row kneeling or sitting from left to right are Ashley Allen, Reed McIntyre, and Katlynne Schaumberg. In the second row standing from right to left are Pat Chappelle, Dana Christenson, Sarah Allen, Rachel Youngberg, Steffi Nuerenberg, Matt Marquardt, and Tanika Ladd. In the back from left to right are Kellianne Lane, Danny Goertz, Alexander Smalldon, Kelley Palmer-McCarty, Scotty Seren, Professor Troy D. Abel, Katie McNett, Graduate Assistant Kathryn Mork, Sean Cooper, Bill Sampson, Patrick Connors, Colin Gaddy, Neddy Dondup, and Professor Andy Bach.