# Proceedings of the First Annual Meeting of the University of Idaho and Tropical Agricultural Research and Higher Education Center (CATIE) IGERT Project

## La Selva and Turrialba, Costa Rica
## July 27 - August 1, 2003

## Biodiversity Conservation and Sustainable Production in Tropical and Temperate Fragmented Landscapes


**Funded by the National Science Foundation Integrative Graduate Education and Research Traineeship Program**

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# UNIVERSITY OF IDAHO – CATIE NSF – IGERT PROJECT
# FIRST ANNUAL MEETING, 27 JULY – 1 AUGUST 2003

## Program

### LA SELVA PORTION

**Sunday, 27 July, Arrive at La Selva (check-in after 12:00 pm)**

| | |
|---|---|
| 6:00pm - | Dinner (La Selva Cafeteria), informal meetings, socializing |

**Monday, 28 July**

**All meetings will take place in the Jaguar Room**

| | |
|---|---|
| 6:00am – 7:00am | Breakfast (La Selva Cafeteria) |
| 7:00am – 10:00am | Free for interaction (unless involved in Advisory Panel meeting) |
| 9:15am – 10:00am | Presentation by IGERT PIs to Advisory Panel |
| 10:00am – 10:05am | Welcome to the Annual Meeting, Nilsa A. Bosque-Pérez |
| 10:05am – 11:00am | IGERT team presentation: Integrated research on causes and effects of forest loss and fragmentation in the agricultural matrix of the Sarapiquí region, **Wayde Morse, Dina Roberts, Steve Sesnie, Jessica Schedlbauer**, Edward Garton, Paul Gessler, Steven Hollenhorst, Kathleen Kavanagh, Bryan Finegan, Celia Harvey, Lucio Pedroni, and Dietmar Stoian |
| 11:00am – 11:40am | IGERT team presentation: Invertebrate biodiversity in the Palouse Prairie: conservation implications, **Chris Looney, Yaniria Sanchez, Richard Cobb**, Sanford Eigenbrode, Jodi Johnson-Maynard, J. D. Wulfhorst, and Nilsa Bosque-Pérez |
| 11:40am – 11:55am | IGERT team presentation: Examining social and biological trends in Interior Northwest forest fragmentation and their implications for biodiversity conservation, **Max Nielsen-Pincus, Amy Pocewicz**, Jo Ellen Force, and Penny Morgan |
| 12:00pm – 1:00pm | Lunch (La Selva Cafeteria) |
| 1:00pm – 2:30pm | Steering Committee meeting |
| 1:00pm – 2:30pm | Fellows meet with Advisory Panel |
| 2:30pm – 3:00pm | Break |
| 3:00pm – 4:00pm | **First Plenary Presentation**: Socio-economic turmoil in the Southeast Alaskan rainforest, **Wini Kessler** |

**Monday, 28 July, cont.**

| | |
|---|---|
| 4:00pm – 5:15pm | Individual Internship Reports:<br><br>A geospatial comparison of breeding habitat models for the flammulated owl (*Otus flammeolus*): an integrated approach, **Steven E. Sesnie, Dina Roberts**, Leona Svancara, J. Michael Scott, Paul Gessler and Edward Garton<br><br>Pollination efficiency of floral visitors of *Geranium viscosissimum*, **Mariangie Ramos**, Nilsa Bosque-Pérez, Olle Pellmyr, and Sanford Eigenbrode<br><br>Social assessment for the Idaho Panhandle National Forests: Prescribed fire and forest health, **Wayde Morse**, Julia Parker, and J.D. Wulfhorst<br><br>Effect of tillage on abundance and activity of the pea leaf weevil (*Sitona lineatus* L.), **Ruth Dahlquist**, Nilsa Bosque-Pérez, Dennis Schotzko, Tim Hatten, and Sanford Eigenborde |
| 6:00pm – 7:30pm | Dinner, informal meetings, socializing (Steering Committee meets with Advisory Panel over dinner) |
| 7:00pm – 8:30 pm | **Second Plenary Presentation**: Implications of intratropical seasonal migrations for reserve design, **George Powell** |

**Tuesday, 29 July**

| | |
|---|---|
| 6:00am – 7:00am | Breakfast (La Selva Cafeteria) |
| 8:00am – 8:55am | Presentation by German Obando, FUNDECOR (Jaguar Room) |
| 9:00am – 5:00pm | Field trip to Sarapiqui CATIE and IGERT research sites and FUNDECOR sites (coordinated by B. Finegan and others) |
| 6:00pm – 7:30pm | Dinner (La Selva Cafeteria), informal meetings, socializing |
| 7:30pm – 8:30pm | **Third Plenary Presentation**: Habitat conservation planning on private lands: headwaters forest in the Pacific Northwest, **Barry Noon** |

# UNIVERSITY OF IDAHO – CATIE NSF – IGERT PROJECT
# FIRST ANNUAL MEETING, 27 JULY – 1 AUGUST 2003

## Program

### CATIE PORTION

**All meetings will take place in the Comunidad Europea (European Community) building**

**Wednesday, 30 July**

| | |
|---|---|
| 6:00am – 7:00am | Breakfast (La Selva Cafeteria) |
| 7:15am | Depart for CATIE |
| 11:00am – 12:00pm | Campus tour for those new to CATIE |
| 11:00am – 12:00pm | The UI-CATIE IGERT graduate education and research project, Nilsa A. Bosque-Pérez |
| 12:00pm – 1:00pm | Lunch (on your own, available at CATIE cafeteria) |
| 1:00pm – 1:40pm | Presentations by CATIE faculty working in the Sarapiquí area, Bryan Finegan |
| 1:40pm – 2:30 pm | Presentation by CATIE faculty working in the Talamanca study area |
| | Biodiversity conservation and sustainable production in small indigenous organic cocoa farms in the Talamanca-Caribe biological corridor, Costa Rica. Eduardo Somarriba, Marilyn Villalobos, Jorge Gonzalez, and Celia Harvey |
| | Biodiversity, cocoa and indigenous people: participatory monitoring of biodiversity in Talamanca, Costa Rica, Celia Harvey and Jorge Gonzalez |
| 2:30pm – 3:30pm | Break |
| 3:30pm – 4:00pm | Presentations by CATIE students working in Sarapiquí |
| | Detecting and mapping of forest types in La Selva-Rio San Juan biological corridor, Costa Rica, Sirpa Rajaniemi and Bryan Finegan |
| | Efectos de la fragmentación en ecología reproductiva de especies arbóreas, Sarapiquí, Costa Rica, Claudia Bouroncle and Bryan Finegan |
| | Efecto de borde y corredores sobre la comunidad de mariposas en un paisaje fragmentado en la zona norte de Costa Rica, Diego E. Tobar and Bryan Finegan |
| 4:00pm – 5:00pm | IGERT team presentation:<br>Integrated research on causes and effects of forest loss and fragmentation in the agricultural matrix of the Sarapiquí region, **Wayde Morse, Dina Roberts, Steve Sesnie, Jessica Schedlbauer**, Edward Garton, Paul Gessler, Steven Hollenhorst, Kathleen Kavanagh, Bryan Finegan, Celia Harvey, Lucio Pedroni, and Dietmar Stoian |
| 5:00pm – 6:00pm | IGERT Sarapiquí team meets with Steering Committee |
| | Dinner on your own (at the CATIE's Social Club or restaurants in Turrialba) |

**Thursday, 31 July**

| | |
|---|---|
| 8:00am – 8:30am | IGERT team presentation:<br>Potential for IGERT interdisciplinary research in the Talamanca region, **Ruth Dahlquist, Beth Polidoro, Jan Schipper**, J. Michael Scott, Matthew Morra, Nilsa Bosque-Pérez, Eduardo Somarriba, Celia Harvey, Luko Hilje, and Eduardo Carrillo |
| 9:00am – 9:30am | Model forest in Costa Rica, Jose Joaquin Campos |
| 9:30am – 9:45am | Break |
| 9:45am – 10:45am | IGERT team presentation:<br>Biodiversity conservation and sustainable production in a coffee-dominated landscape, **Christopher M. Lorion, Mariangie Ramos, Edgar Varón**, Jeffrey Braatne, Nilsa Bosque-Pérez, Sanford Eigenbrode, and Luko Hilje |
| 10:45am – 12:15pm | Participating faculty and Advisory Panel debriefing |
| 11:30am – 12:30 pm | Advisory Panel Meeting with fellows |
| 12:00pm – 1:00pm | Lunch (on your own, available at CATIE cafeteria) |
| 1:00pm – 5:00pm | Trip to coffee research sites (coordinated by L. Hilje and others) |
| 7:00pm - | Dinner and socializing (Pochotel) |

**Friday, 1 August**

| | |
|---|---|
| 7:00am - | Leave for Talamanca (coordinated by E. Somarriba and others) |
| All day | Meetings between CATIE and UI faculty and IGERT fellows |

# CATIE – University of Idaho NSF –IGERT Project
# First Annual Meeting

## Program For Field Trip, Tuesday July 29

| | |
|---|---|
| 6:00am – 9:00am | For activities, see main meeting program |
| 9:00am – 10:30am | Visit to private farm managed under agreement with FUNDECOR, Horquetas (FUNDECOR personnel) |
| 10:30am – 3:00pm | FRAGMENT project research sites, Río Frio area (Celia Harvey, CATIE and project personnel)<br><br>**1. Introduction to the Fragment Project in CATIE**<br>Celia Harvey<br><br>**2. Biodiversity component**<br>Celia Harvey<br><br>**3. Farm diagnosis**<br>Cristóbal Villanueva<br><br>**4. Characterization of cattle farms and tree cover in Río Frío**<br>Jaime Villacís<br><br>**5. Evaluation of fragments and landscape connectivity in Río Frío**<br>Mario Chacón<br><br>Also, we will be visiting three farms, which are representative of production systems in the zone, such a: dairy cattle, beef cattle and mixed (cattle and agriculture).<br><br>*note* – packed lunch will be taken in the field during the time with the FRAGMENT project |
| 3:00pm – 4:30pm | Human impacts on vegetation and perspectives for conservation and restoration in an anthropogenic landscape, research site in northern Sarapiquí (Bryan Finegan, CATIE) |
| 5:00pm | Return to La Selva |

## Interdisciplinary Research Report
## Potential for IGERT Interdisciplinary Research in the Talamanca Region: Conservation and Sustainable Production

**Ruth Dahlquist, Beth Polidoro, Jan Schipper, Nilsa A. Bosque-Pérez, Luisa Castillo, Eduardo Carrillo, Matthew Morra, J. Michael Scott, and Eduardo Somarriba**

The Talamanca Region of south-eastern Costa Rica presents an excellent case study in biodiversity conservation and for sustainable agricultural production. An IGERT team would be able to address the effects of human land use on species distribution and population viability, reserve design and management, soil and water quality, and agricultural production at various spatial scales. Research questions would focus on preexisting conservation and agricultural production issues identified by the various government and non-governmental agencies working in the area. Results could then be presented to organizations involved in management of protected areas and sustainable agricultural development.

The Talamanca mountain range extends from southern Costa Rica to northern Panama and is among the largest blocks of protected forest in Central America. The Caribbean slope remains largely intact with relatively high habitat connectivity, while the Pacific slope has been degraded to just a few sizable forest remnants in the most inaccessible areas. The Caribbean slope includes protected areas, several indigenous reserves, and commercial banana plantations. We propose to examine the effects of various management strategies on the conservation of biodiversity and sustainable agricultural production. Scales of analysis will vary from regional (greater Talamancas), to landscape (Bribri-Cabécar Reserve), to site-specific (individual farms).

Disciplinary research areas represented in interdisciplinary research topics:
1) Habitat-based conservation planning and predicting the effects of fragmentation on the long-term persistence of area-sensitive mammals
2) Fate and transport of pesticides including biological toxicity
3) Integrated pest management of the banana weevil for small-scale farmers

At the largest spatial scale research would focus on the entire range of corridors that connect the Talamanca mountains to Corcovado on the Pacific coast and Gandoca-Manzanillo on the Caribbean coast. These include the Fila Carbon corridor connecting La Amistad International Peace Park with the Caribbean coast and the Fila Costeña corridor connecting La Amistad with the Pacific. In the context of metapopulation ecology, the La Amistad park acts as a potential source of many area-sensitive species, while the isolated coastal parks act as population sinks. On the Caribbean slope, forest areas including agroforestry production systems will be evaluated for their ability to provide suitable habitat for movement of target mammal species. A strong mapping component would include using a geographical information system (GIS) to model mammalian species and habitat distributions as well as updating current remaining forest cover, human population density, and land-use maps. These maps would be employed to conduct an analysis of the gaps in protection of representative habitat types and target species.

At the landscape scale, research would focus on regional agricultural practices that affect aquatic resources in the Bribri-Cabécar indigenous reserve. Testing of major rivers, river sediments and rainwater will assist in determining the type, concentration and possible sources of pesticide contamination affecting water quality in the reserve. Presence and concentration of pesticide contamination will be used to develop biological toxicity tests for aquatic organisms determined to be indicators of water quality.

At the farm scale, research would focus on improving the productivity and sustainability of agroforestry systems through development of integrated pest management (IPM) practices for control of the banana weevil (*Cosmopolites sordidus*). Various management techniques will be evaluated for their efficacy in control of the weevil and their potential for integration with other agricultural practices. Results will assist local farmers in determining best management practices for organic banana production.

Integrated research areas

**Effects of intercropping on pest control and mammal movement**

Agroforestry systems in the Bribri-Cabécar Reserve vary greatly in the diversity of crops cultivated. Systems range from banana monocultures to intercrops of cacao, banana, and timber species to traditional systems where cacao and banana are cultivated under a canopy of forest tree species. These systems of varying vegetational diversity could be evaluated both for their levels of banana weevil population density and damage and for their ability to provide suitable habitat for movement of target mammal species. Agroforestry systems with cacao and forest species are of particular interest for conservation in the region because they can provide important habitat for many species, and there is concern that economic pressure will drive the conversion of diverse cacao systems to less diverse agricultural production. Diversified farming systems also may have reduced levels of pests. Previous studies have shown that intercropping banana with other crops reduces banana weevil populations, but may decrease yield due to competition (Karamura and Gold 2000). Research on intercropping banana and plantain with other tree species including cacao would clarify its effects on weevil population density and damage as well as yield. The incorporation of intercropping into an integrated pest management program for the banana weevil could provide an added incentive for the use of diverse tree species that may provide habitat for the movement of wildlife.

**Effects of river pesticide concentration on aquatic mammals**

Many carnivorous mammals that utilize aquatic resources for food, habitat or movement may be affected by the bioaccumulation of pesticides and their degradation products in aquatic ecosystems. In the Talamanca region, pesticides can be redistributed from the application area and deposited into aquatic resources through erosion of contaminated sediments, leaching into groundwater, atmospheric drift, or volatilization and precipitation. Intensive pesticide use, application type, and toxicity of compounds used combined with high precipitation can pose a threat to aquatic ecosystem function and community composition. For example, several fish kills have been recorded in the U.S. and in Costa Rica after application of a nematicide followed shortly by rain events

(Castillo et al. 2000). Previous studies indicate that even with low levels of selected pesticides, community richness and composition of benthic macroinvertebrates can be radically altered (Castillo et al. 1999). If pesticide applications are not immediately fatal to the system, persistent bioavailable compounds in sediments and in the water column can bioaccumulate over time in aquatic flora and fauna. Mammals that ingest contaminated flora and fauna are at risk of bioaccumulation as well as potential loss of important food sources.

**Sustainable Banana Production**

Bananas are one of Costa Rica's most important cash crops. In the Bribri-Cabécar reserve, banana production is mostly organic, and indigenous farmers are concerned with reducing banana weevil populations without pesticides while maintaining yields and fruit quality for the organic market. Nonchemical control methods will assist farmers in maintaining and improving sustainable banana production. Extensive pesticide use in regional banana cultivation that may threaten water quality and pose a risk to public health is not a sustainable practice. Determination of presence, concentration and source of pesticides in aquatic resources will assist community leaders in developing strategies to reduce pesticide contamination in the reserve and to promote more sustainable agricultural practices in the region. Results might also be useful in the development of socioeconomic analyses of agricultural practices including costs, labor requirements, economic benefits, and feasibility.

Research would be conducted in collaboration with local and international government and non-governmental organizations. Conservation planning research partners would include MINAE, SINAC, World Wildlife Fund – Central America, Conservation International, and the Mesoamerican Corridor Project. Mapping of mammalian area of occupancy would be conducted in collaboration with InBio's ECOMAPAS project, Universidad Nacional Autonoma's Programa Regional de Maestria Vida Silvestre (UNA-PRMVS), and the Curator of Mammology at the National Museum. Pesticide research within the reserve will be conducted under the guidance of ANAI and APPTA, with laboratory analysis at the Universidad Nacional. Pest management research will be in collaboration with APPTA and local indigenous councils in the reserve.

## References

Castillo, L. E., E. Martinez, M. Gilek, M. Pinnock, C. Ruepert, and C. Savage. 1999. Water quality and macroinvertebrate community response following pesticide applications in a banana plantation, Limon, Costa Rica. Department of Systems Ecology Dissertation, Stockholm University, Sweden.

Castillo, L. E., R. Clemens, and E. Solis. 2000. Pesticide residues in the aquatic environment of banana plantation areas in the north Atlantic zone of Costa Rica. Environmental Toxicology and Chemistry **19**:1942-1950.

Karamura, E. B., and C. S. Gold. 2000. The elusive banana weevil *Cosmopolites sordidus* Germar. Acta Horticulturae **540**:471-485.

**Interdisciplinary Research Report**
# Invertebrate Biodiversity in the Palouse Prairie: Conservation Implications

**Chris Looney, Yaniria Sánchez-de León, Richard Cobb, Sanford Eigenbrode, Jodi Johnson-Maynard, J. D. Wulfhorst, and Nilsa A. Bosque-Pérez**

Habitat destruction of native grasslands on the Palouse has resulted in a fragmented landscape of small habitat remnants embedded in a matrix of converted land (*sensu* McIntyre and Hobbs 1999). Habitat loss and patch isolation on the Palouse is extremely high, with approximately one percent of the original prairie habitat remaining (Black et al. 1998). Conservation planning in such a landscape presents several challenges, due to the magnitude of isolation and small size of habitat remnants (McIntyre and Hobbs 1999). The modern Palouse prairie matrix is composed of agricultural fields where crop rotation practices determine the dominant vegetation. Another major land-use is conservation reserve program (CRP) lands dominated by exotic annual grasses. Finally, native Palouse prairie ecosystems are a small but important component of the Palouse matrix.

The deep wind blown loess deposits and favorable climate support highly productive dry land agriculture. Crop rotation practices determine the dominant vegetation in the matrix. Two rotations of wheat (one fall-sown, one spring-sown) are typically followed by one rotation of legumes (pea, lentil, or chickpea). Conservation tillage strategies including reduced and no-till practices have been adopted by many farmers to reduce soil erosion and conserve water and are likely to have benefits for invertebrate populations in crop systems (Stinner and House 1990).

Most CRP lands currently enrolled on the Palouse are planted primarily with exotic perennial grasses (Bertie Weddell, personal communication to C. Looney). Few native grasses, or forbs and shrubs of any origin, are planted in CRP set-asides. Increasing the use of native and diverse plants is a new CRP goal, and is expected to provide greater environmental benefits (USDA 1999). In addition to the anticipated benefits to soil resources, water quality, and wildlife habitat, increasing plant diversity may have conservation benefits for terrestrial invertebrates.

Prairie remnants are grasslands usually located on steep or rocky slopes and are often associated with ponderosa pine stands. Vegetation in the prairies is composed mainly of Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Psuedoregneria spicata*), snowberry *(Symphoricarpos albus*), black hawthorn (*Crataegus douglasii*) and rose (*Rosa* spp.) (Lichthardt and Mosley 1997). These habitats may have high invertebrate diversity but are highly fragmented and isolated. Exotic species establishment and development are serious threats to these systems.

Invertebrate species are important for several reasons. Invertebrates provide much of the food for vertebrate species, are important nutrient recyclers, and processors of dead plant and animal matter. The natural enemy and pollinator services provided by insects are irreplaceable and have great economic value. We have selected epigeic (litter dweller) arthropods and earthworms because they are ubiquitous and cosmopolitan; they represent a significant proportion of regional biodiversity in almost all habitats (Wilson 1992), fulfill numerous ecosystem functions (Brussaard et al. 1997; Groffman and Bohlen 1999), and can add considerable services to agricultural areas as natural enemies (e.g. Kromp 1999). In addition, identification of insects which potentially vector viral pathogens can help to elucidate threats to native vegetation. We will concentrate our research program on the Conservation Reserve Program (CRP) lands, the productive agricultural lands, prairie remnants and adjacent ponderosa pine forests of the Palouse. These general land use types represent the vast majority of acreage on the Palouse. We will focus our studies on ground dwelling beetles, earthworms and aphid populations.

Ground dwelling beetles include several taxa that play central roles in ecological functioning. For instance, the families Silphidae and Histeridae are important in the cycling of dead organic matter (Arnett and Thomas 2000). The Carabidae (ground beetles) are thought to provide numerous services as natural enemies (Kromp 1999). Ground dwelling beetles are also relatively easy to sample, and several families (e.g. Staphylinidae) have proved useful as habitat indicators (Bohac 1999). Other than preliminary work began by our colleagues last year (Hatten et al. 2002), no attempt has been made to understand the distribution and habitat associations of beetles in the Palouse. On a larger scale, few (if indeed, any) investigations have focused on insects of any kind associated with CRP lands.

The objective of this summer's work with ground dwelling beetles was to continue characterizing the ground dwelling beetle fauna of remnant Palouse prairie habitats, and to begin to understand the beetle fauna of CRP lands. Hatten et al. (2002) collected ground dwelling beetles using pitfall traps during the summer of 2002. However, they were only able to sample the remnants during the later part of the season (late June through August). We began sampling five remnants earlier in the season (mid-May), in order to ensure that spring active species were represented in our characterization. We used pitfall traps of approximately 6.5 cm diameter armed with a 50:50 propylene glycol:water mixture as a killing agent and preservative. Traps were arranged in each habitat in transects of eight traps. Two traps were randomly located at four equidistant points in each transect. Two transects were installed in different stands in each remnant; one transect each in stands with and without a shrub overstory. Traps were opened every other week. At the end of each week, traps were collected and returned to the lab for processing. All beetles will be sorted to morpho-species.

The same methodology was used to begin characterizing the ground dwelling beetles utilizing CRP lands. Five CRP sites were sampled. Four of the sites were adjacent to the four large prairie remnants we sampled; one site was located away from a remnant. Traps were deployed and collected on the same dates as the prairie remnants, and returned to the lab. The data from these habitats will begin to identify species characteristic of Palouse remnant habitats, as well as species able to use a significant land type in the matrix.

Earthworm communities are important members of the soil macrofauna (Edwards and Bohlen 1996). Earthworm diversity has been related to critical soil ecosystem functions such as decomposition, nutrient cycling, and maintenance of soil structure (Groffman and Bohlen 1999). We concentrated earthworm diversity studies this summer in Palouse prairie remnants, CRP lands and ponderosa pine patches. Earthworm community structure is unknown for prairie remnants and CRP lands. Our research question was: Is earthworm diversity in prairie, CRP and ponderosa pine forests different? We hypothesized that earthworm diversity will be higher in prairie remnants than in ponderosa pine forests and will be less in CRP due to higher plant and habitat diversity and lower disturbance in prairies and ponderosa pine forests. Three research sites were located in the Palouse region in northern Idaho. Each site contained adjacent representatives of all three habitat types. We collected earthworms from six 25 x 25cm pits that were excavated manually to a depth of 30 cm at each of the study sites. Earthworms were counted and fresh weight was recorded. We identified earthworm species using the taxonomic key by Schewert (1990). We only found two earthworm species: *Aporrectodea trapezoides* and *Lumbricus* sp. Prairies were dominated exclusively by *A. trapezoides*. Mean earthworm density was 67 (individuals/$m^2$) in prairie remnants, 107 (individuals/$m^2$) in CRP lands and 47 in ponderosa pine forests. Mean earthworm fresh weight was 37 (g/$m^2$) in prairies, 45 (g/$m^2$) in CRP lands and 25 (g/$m^2$) in ponderosa pine forests. Earthworm diversity was not higher in prairie remnants than in other land uses studied. Native earthworm species of our study areas were probably eradicated by changes in habitat or by competition with exotic species. Other soil factors, such as depth, pH or carbon and nutrient concentration in these sites may explain earthworm density or biomass distribution in these areas.

Pea aphid (*Acyrthosiphon pisum*) is an efficient vector of over 30 plant viruses and is polyphagous within the fabaceae family. Viral pathogens vectored by this insect are of great concern in both the agricultural and natural systems on the Palouse. A system of pathogen monitoring stations consisting of yellow pan traps located next to pea varieties susceptible to regionally important viruses was established in May 2003 with the objective of building a long-term dataset of aphid vectored pathogens on the Palouse. This effort was augmented with sampling for pea aphid in native grasslands. Pea aphid was recovered in two native grasslands during May, the period of immigration from the Columbia basin to the Palouse. Alate pea aphids were recovered in low numbers at the research farms during May. Populations gradually increased over the course of the growing season. Aphid counts within study plots (30 by 30 m pea plots planted with the variety "Joel") were low in June and increased gradually to a peak in mid July. Symptoms consistent with *Pea seed borne mosaic virus* (PSbMV) were documented in all study plots and were most severe in the plots with the greatest aphid densities ($r^2 = 0.80$; $p < 0.001$). Plant tissue from two native lupine species was collected from three native grassland sites. These samples will be assayed for the presence of exotic pathogens using polymerase chain reaction. Pea tissue from study plots was collected and will be analyzed to confirm the presence of PSbMV. Initial results suggest this system of monitoring will be an effective technique for following year to year variability in vector and viral populations.

The baseline data generated by these three studies will be used as we continue to develop an integrated research approach. Some potential overarching interdisciplinary questions that we are currently considering include:

- How to manage matrix for the maintenance of ecosystem function and social values?
- Could regional management based on application of tillage practices and judicious distributions of CRP lands improve the connectivity of prairie remnants for key plant or animal species?
- Are there opportunities to improve community awareness of the biological uniqueness and fragility of the Palouse?

- Do existing remnants differ in susceptibility to invasion by exotic weedy plant and animal species? If so, what characteristics are associated with resistance to invasion?

We anticipate that these preliminary questions will be further developed after new students contribute their research interests to this project.

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## Interdisciplinary Research Report
## Integrated Research on the Causes and Effects of Forest Loss and Fragmentation in the Agricultural Matrix of Sarapiquí

**Wayde Morse, Dina Roberts, Jessica Schedlbauer, Steven Sesnie, Bryan Finegan, Celia Harvey, Lucio Pedroni, Dietmar Stoian, Edward O. Garton, Paul Gessler, Steven Hollenhorst, Kathleen Kavanagh, and J. Michael Scott**

### Interdisciplinary Research Summary

Forest loss and fragmentation are pervasive threats to maintaining biodiversity and productive forest systems in Latin America. These processes contribute to a complex agricultural matrix where many species rich habitats remain among forest remnants and agroforestry systems. Complex human/ecosystem interactions illustrate the need to focus research on biodiversity conservation and ecosystem change within intensively managed landscapes. Our objective is to enhance knowledge on land use practices compatible with maintaining biodiversity in the North Atlantic Zone of Costa Rica. Integrated research is designed to fill voids in knowledge about plant and animal distributions, habitat use, edge effects, and human land use patterns. Research activities include: 1) a cross validation of avian species habitat models with actual habitat selection, 2) a comparative analysis of farmer perceptions of factors driving land use decisions and actual land change, and 3) an evaluation of the long-term viability of conservation programs in maintaining forest remnants. The majority of this information will be used to identify a data integration framework for Gap analysis procedures within tropical landscapes. We expect that the results of this research will improve understanding of the role of regional and national conservation programs for sustaining forest cover and desired levels of biodiversity. Decision support systems and scientific information validated through this study will contribute to adaptive conservation activities in the Sarapiquí Region of Costa Rica.

### Disciplinary Research Areas

1. Validating a remote sensing based land classification framework for identifying land cover types and change detection
2. The effects of forest fragmentation on survivorship and habitat use of key seed-dispersing avian species
3. Factors and facilitators driving farmer production and management decisions about land use
4. The role of edge effects in shaping forest structure and carbon storage in fragmented landscapes

### Integrated Research Areas

### Gap Analysis

A component of our research focuses on verifying Gap analysis procedures appropriate for landscapes in the Neotropics. Gap analysis is a useful tool to support regional conservation planning (Davis and Stoms 1996), by identifying priority locations and practical limits to the amount of area managed for biodiversity (Csuti and Kiester 1996). Data sources incorporated into a Gap Model include: 1) a vegetation classification and land cover types layer, 2) animal distribution layer, 3) stewardship and management information (Scott et. al. 1993, Forester et al. 1996). Gap procedures for complex tropical landscapes and ownerships are not currently defined. Habitat models for focal species along with techniques to assess the conservation status among private lands are essential for conservation priority setting. Our research will develop each of the three primary layers of Gap analysis for the pilot study area (~2,500 $km^2$).

**Research components**

***A. Cross validation of avian species habitat models with actual habitat selection***

This research combines floristically based land cover classes with frugivorous bird habitat associations for habitat modeling. We will then test the level of congruence between actual and predicted habitat using a portion of the bird survey data for cross validation.

***B. Farmer perceptions of factors driving land use decisions and land change***

Land use decisions made by private land owners will be compared with actual land cover changes quantified using satellite images. Regions of rapid land changes will be correlated with spatial and temporal factors identified during land owner surveys. These comparisons will corroborate assumptions about the conservation status of private lands included in a stewardship layer.

***C. Gap Analysis***

Digital data layers will be integrated as a preliminary assessment of land conservation status for focal bird species habitats. We will generate a map and database of conservation priority areas for these species within the study area.

**Potential Integrated Research**

Possibilities for answering integrated research questions will be considered as preliminary data are collected and analyzed. At least three of these ideas are dependent upon outputs of data analysis that will not be ready for six months to a year. First, if research sites selected to study edge effects are within different forest classes, it will be possible to compare edge effects across forest types. Second, linking research at the landscape scale and combining data collected from bird radio-telemetry work with the edge effects study. Third, results of social research on decision making and data from edge effects study could be combined for analyzing edge creation.

**Related team activities and progress**

- April and June 2003; team members relocated to Costa Rica to set up dissertation research
- May, June, and July 2003; research logistics, research setup, and administrative tasks

- Research plans of all team members have been revised in light of input from CATIE committee members, faculty, and research collaborators
- Team members have consulted with collaborating organizations and projects in Costa Rica (including FUNDECOR, the CATIE Forest Fragment Project, and the CATIE/GEF Silvopastoral Project) to aid in research planning
- Research and export permits have been initiated through MINAE
- Preliminary data collection and some research plots have been established

**Expected interdisciplinary outputs and publications**

- A team publication addressing broad scale conservation issues and integrated research (Possible venue: Bioscience)
- A concept paper pertaining to graduate-level integrated research
- Gap analysis dissertation chapter and Publication (Possible venue: Agriculture, Ecosystems, and Environment)

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**Interdisciplinary Research Report**
**Conservation and Sustainable Production in a Coffee Dominated Landscape**

**Mariangie Ramos, Christopher Lorion, Edgar Varón, Luko Hilje, Sanford Eigenbrode, Nilsa A. Bosque-Pérez, and Jeffrey Braatne**

## Introduction

It has been suggested that a central focus of modern conservation biology should be the maintenance of biodiversity in landscape mosaics composed of different land uses and natural habitats (Lubchenco et al. 1991), both aquatic and terrestrial. To achieve biodiversity conservation throughout the landscape, research should focus in two important objectives, (1) the identification and preservation of landscape elements that maximize biodiversity and (2) the evaluation and reduction of negative impacts on biodiversity in human-exploited mosaic elements (Bestelmeyer and Wiens 2001), like agricultural areas.

Agricultural areas are dominant components of the landscape in many regions of the world. They may support high biodiversity depending on their management practices (Moguel and Toledo 1999). In tropical areas, coffee is a major crop because of its high economic importance (second only to petroleum as an international commodity; FAOSTAT-online http://apps.fao.org). Management practices in coffee cultivation may affect the capacity of these agroecosystems to sustain biodiversity (Moguel and Toledo 1999, Perfecto et al. 1996). Previous studies have focused on the effects of shade canopy diversity and chemical inputs in coffee farms on biodiversity (Moguel and Toledo 1999). The maintenance of riparian forests along streams and rivers in coffee farms has not been examined, although it may influence biodiversity conservation and production in coffee-dominated landscapes.

Question 1: How do riparian strips promote biodiversity maintenance in coffee dominated landscapes?

## Justification

Riparian strips of forest are often left in agricultural areas, either due to law or unsuitability for cultivation (de Lima and Gascon 1999). They could be important landscape elements for the maintenance of biodiversity, because they provide habitat and may serve as dispersal corridors (Laurance and Laurance 1999). Furthermore, riparian zones are considered critical transition zones between terrestrial and aquatic ecosystems (Bardgett et al. 2001). Therefore, they could play a key role in maintaining aquatic ecosystem diversity, in addition to providing terrestrial habitat in highly fragmented landscapes.

Riparian zones provide habitat for a variety of terrestrial organisms in fragmented landscapes (de Lima and Gascon 1999, Laurance and Laurance 1999). For example, bees rely on vegetation for foraging, nesting, oviposition, resting and mating (Kevan 1999). Riparian zones probably offer alternative sites for these activities in agricultural areas, where vegetation is often removed (Kevan 1999). Ruszkowski et al. (1993) found that in some months, the highest density of bumble bees in Pulawy, Poland was observed in riparian areas, as opposed to agricultural fields or forest. Riparian zones may also provide food resources for soil fauna, such as ants.

Riparian areas are also important for regulating fluxes of nutrients and sediment at the land-water interface. These functional relationships are vital for the maintenance of stream ecosystem function and diversity (Karr and Schlosser 1978). Riparian zones regulate stream ecosystem trophic structure, filter sediments, and contribute to stream habitat diversity (Gregory et al. 1991). In fact, some studies have found that stream substrate (Nerbonne and Vondracek 2001), as well as fish and macroinvertebrate assemblages (Sponseller et al. 2001; Stewart et al. 2001), are more closely correlated with riparian condition than land-use characteristics of a basin as a whole.

2. How do riparian forests affect coffee production?

**Justification**

Riparian forests are protected by law in Costa Rica, but this regulation is often ignored (Pringle and Scatena 2001). Nevertheless, riparian strips are occasionally retained in coffee plantations and may influence coffee production. These riparian forests may occupy areas that would otherwise be used for production, although in many cases riparian areas are unsuitable for cultivation. In addition, riparian areas may affect populations of insects that could either benefit or decrease production.

Although coffee is self-pollinated (autogamous), it could benefit from pollination by bees, resulting in higher yields (Badilla and Ramirez 1991, Roubik 2002). Riparian forests could provide nesting, foraging and oviposistion sites for bees in coffee plantations, especially when coffee trees are not flowering. Bees could move from the riparian forests to farms, helping coffee production. For example, in watermelon plantations in California, it was shown that organic farms near natural habitat fragments could receive full pollination services from native bee communities (Kremen et al. 2002). In addition, riparian strips may sustain other beneficial hymenoptera, like parasitic wasps, that may control coffee pests, like the coffee berry borer and the coffee weevil.

Leaf-cutting ants are important pests that attack most kinds of vegetation and are pre-adapted for their role as agricultural pests by their ability to use many plant species with the aid of their symbiotic fungi. In a survey of 27 countries, Cherrett and Peregrine (1976) found that coffee was one the most often damaged crops by leaf-cutting ants. Riparian forest fragments provide food resources for leaf-cutting ants in agricultural landscapes, and we have found that nests of leaf-cutting ants are concentrated at the edge of riparian forests. Thus, riparian forests may act as a buffer against leaf-cutting ant damage to coffee plants or promote the colonization of leaf-cutting ants in coffee fields.

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**Disciplinary Research Plan**
**Management of the Banana Weevil (*Cosmopolites sordidus* Germar) in Talamanca: Potential Research Directions**

**Ruth Dahlquist and Nilsa A. Bosque-Pérez**

In Talamanca, banana and plantain cropping systems range from monoculture to an intercrop with cacao, and timber species, to a traditional system in which cacao and banana are cultivated under a diverse canopy of forest tree species (Somarriba and Harvey 2002). Cacao agroforestry systems with diverse tree canopies are of interest for conservation because they provide important habitat for a variety of species. Sustainable production in this area is needed to prevent the conversion of cacao plantations to less diverse land uses and the clearing of forest fragments for annual crop production (CATIE 2000). The banana weevil (*Cosmopolites sordidus* Germar) is an important pest on bananas and plantains in these systems (E. Somarriba pers. comm.) and throughout the tropics (Karamura and Gold 2000). Improved management of the banana weevil in the cropping systems of Talamanca will contribute both to the sustainable production of bananas and plantains in diverse agroecosystems and to biodiversity conservation in the region.

While the banana weevil is not a major problem in commercial plantations, it has eluded control in smallholder production systems. Farmers use various control measures, but not all have been evaluated widely for their efficacy or potential integration with other practices (Karamura and Gold 2000). These measures include cultural controls such as clean planting material, intercropping, destruction of residues after harvest, and trapping. Karamura and Gold (2000) identify several gaps in knowledge that limit the development of integrated pest management recommendations for the banana weevil. The effect of intercropping on weevil populations and damage is not well understood. Also, many cultural controls have not been fully evaluated for their efficiency, effects on weevil populations and damage, and effects on nutrient cycling and yield.

In light of the current gaps in information for banana weevil management in the tropics and the need for sustainable production in Talamanca, two potential directions for research are proposed: biological control, and cultural controls such as intercropping, removal of post-harvest residue, and trapping. Here we present possible research questions for the use of predatory ants as biological control agents, intercropping with cacao and timber species, and removal of residue.

### Predatory ants

The ant species *Tetramorium guineense* and *Pheidole megacephala* have been used successfully for biological control of the banana weevil in Cuba (Karamura and Gold 2000). *T. guineense* preys on the larvae, and *P. megacephala* prevents females from ovipositing on the plant. Control is achieved by transporting ant colonies into the banana plantation where they become established. If ant species which prey on the banana weevil are present in Talamanca, control of the weevil might be enhanced through transporting colonies or attracting individuals with bait. Since little is known about ant communities in Talamanca, the first step would be to assess ant biodiversity in the various agroforestry systems.

Potential Question: What is the effect of crop diversity on the ground foraging ant community in cacao and banana agroforestry systems?
Hypothesis: Ant biodiversity will be higher in agroforestry systems with higher crop diversity.

**Intercropping**

Diversification of cropping systems often reduces pest populations (Altieri 1999). Studies on intercropping banana with crops such as sweet potato and millet indicate that intercropping may reduce weevil populations, but that yields may be lower due to competition for nutrients (Karamura and Gold 2000). Since intercropping is currently used by farmers in Talamanca, its contribution to control of the banana weevil could be evaluated. Diversified systems in which banana or plantain is intercropped with trees such as cacao and timber species (e.g. *Cordia alliodora, Cedrela odorata*) could be compared to monocultures to evaluate the effects of intercropping on both yield and weevil damage.

Potential Question: Do levels of banana weevil damage and population density vary with diversity of vegetation in cropping systems?
Hypothesis: Agroforestry systems with higher vegetational diversity will have lower weevil population density and levels of insect damage.

**Removal of residue**

The removal and destruction of banana corms and pseudostems after harvest are practiced widely (Karamura and Gold 2000). However, these activities are labor-intensive, and controversy exists over their effectiveness. Some scientists claim that post-harvest stumps should be left in the field to draw ovipositing weevils away from young banana suckers and to provide suckers with nutrients as the stumps decompose. However, weevils emerging from eggs laid in stumps may increase the field population overall, and nutrients from stumps may become available over time if chopped residues are used as mulch. To evaluate the efficacy of removing post-harvest residue, data on the effects on weevil populations and nutrient cycling are needed (Karamura and Gold 2000).

Potential Question: What is the long-term effect of removing post-harvest residue on banana weevil population density and damage?
Hypothesis: Removing residue will decrease population density and damage over time.

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# Disciplinary Research Report
# Epigeal Coleoptera of Palouse Prairie Remnants and CRP Plantings

**Chris Looney and Sanford Eigenbrode**

## Introduction

Habitat conversion in the Palouse region of northern Idaho over the past century has left only about one percent of the pre-European "prairie" habitat intact (Black et al. 1998). Today, very small prairie remnants are embedded in a matrix of agriculture-dominated land. Palouse prairie natural history and ecology have generally focused on plants, with little attention paid to invertebrate communities (e.g. Tisdale 1961, Daubenmire 1970, Noss 1995, Lichthardt and Mosley 1997, Black et al. 1998, Weddell 2001). Insect diversity is particularly important to ecosystem functioning; insects pollinate most angiosperms (Wilson 1998), and are key trophic links (Price 1997). Epigeic coleoptera in particular represent a significant proportion of regional biodiversity in almost all habitats (Wilson 1992).

As with remnant Palouse habitats, little description of the insect communities of Conservation Reserve Program lands is available. More than 180,000 acres of previous Palouse cropland are enrolled in the CRP program. CRP set asides could provide refugia for many insect species and be important to regional biodiversity (Thomas 1990, Bujaki 1992, Desender and Bosmans 1998, Tscharntke et al. 2002). CRP lands may also provide refugia for agricultural pests or invasive exotics, which could complicate Palouse prairie restoration and conservation.

CRP could play an important role in restoration and conservation efforts. Current CRP guidelines encourage the planting of forbs, shrubs, and trees, and native species. CRP lands may be candidates for active restoration, as they are relatively low value agricultural lands. Many new owners of CRP may be likely to keep the land in set-aside even if CRP leases expire (Black et al. 1998). This summer's work is intended to provide a baseline description of the epigeal insect communities that may be expected in remnant Palouse habitat and CRP land.

## Methods

Five Palouse prairie remnants sampled by Hatten et al. (2002) were re-sampled between May and August 2003. Three habitats are located in Whitman County, Washington: Smoot Hill, Rose Creek, and Kramer Prairie. Two remnants are located in Latah County, Idaho: Tomer Butte, and Paradise Ridge. Five CRP plantings were also sampled during the same time period.

Transects of pitfall traps were used to sample both land uses. Each transect had four equidistant sampling points 30 meters apart. At each point, two randomly placed traps were installed. Traps were installed in May 2003, and will be maintained through August 2003. Community structure metrics will be calculated for each site. The proportion of diversity will also be analyzed by functional group, disturbance tolerance, and exotic vs. native species.

**Results expected**

Very little information has been published describing the insect communities of Palouse Prairie. This work will provide baseline data for epigeal Coleoptera found in Palouse prairie remnants and CRP land. The CRP data in particular will be important for formulating landscape scale ecological questions, as well as providing a significant contribution to our knowledge of agricultural landscapes.

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## Disciplinary Research Plan
## Stream Food Webs in a Fragmented Tropical Landscape

**Christopher Lorion and Jeffrey Braatne**

Degradation of freshwater ecosystems has occurred throughout Costa Rica, and has many different causes, including deforestation, agricultural runoff, and pollution associated with urban development (Bussing 1998). The consequences for aquatic biodiversity have not been well-studied, although it has been noted that 9% of Costa Rica's freshwater fish fauna is either endangered, threatened, or of special concern (Moyle and Leidy 1992). Costa Rican law affords some protection for aquatic ecosystems by prohibiting the clearing of forests adjacent to streams. However, these regulations are not strictly enforced and are often ignored (Pringle and Scatena 1999).

Disturbance or removal of natural riparian vegetation has important consequences for adjacent aquatic habitats, as riparian zones are known to play a vital role in maintaining stream ecosystem function and diversity (Karr and Schlosser 1978). Riparian vegetation provides shading, contributes leaf litter and large woody debris, and can filter nutrients and sediments from runoff. These functions support the maintenance of stream habitat diversity and regulate the exchange of nutrients and sediment between streams and the surrounding terrestrial habitats (Gregory et al. 1991). The influence of the riparian zone is particularly important in headwater streams, which have a proportionally larger interface with surrounding terrestrial ecosystems. In small streams bordered by intact riparian forests, shading often limits algal production. As a result, food webs in undisturbed headwater streams are expected to be dependent on allochthonous inputs, carbon sources such as leaf litter that come from outside the stream (Vannote et al. 1980). Loss of riparian forests alters the supply of organic material to stream food webs, which can have significant negative consequences for stream biota (Wallace et al. 1997).

In August 2003, we will begin investigations into the relationship between riparian forest fragments and stream food webs in low-order streams in the Reventazón River basin near Turrialba, Costa Rica using stable isotope analysis. Algal stable carbon isotope ratios ($^{13}C/^{12}C$ or $\delta^{13}C$) are usually distinct from those of terrestrially derived carbon in small streams (Finlay 2001). Furthermore, $\delta^{13}C$ values change very little with trophic exchange, and so these differences can be used to determine whether consumers in aquatic communities depend more on terrestrial carbon inputs or primary production within the stream (Junger and Planas 1994). Stable nitrogen isotope ratios ($^{15}N/^{14}N$) provide additional data on trophic structure, and can be used in combination with $\delta^{13}C$ values to diagram aquatic food webs (Fry 1991). This dual-isotope method has been used to describe food webs in neotropical streams (Kilham and Pringle 2000), but work in Costa Rica has been limited to a single, low elevation stream draining primary forest. Information is lacking for both montane streams and for watersheds where forest cover is highly fragmented.

In the current study, sites will be chosen to represent a range of riparian conditions, from heavily shaded streams with intact riparian corridors to sites where riparian forests have been completely removed. One stream draining a largely undisturbed basin will also be sampled for comparison. Samples of leaf litter, algae, aquatic insects and snails, and fish fin tissue will be collected at each site and transported to the University of Idaho

Stable Isotopes Laboratory for analysis during fall semester 2003. Taxonomic composition of macroinvertebrate samples will also be determined. The results of this study will provide a better understanding of the effectiveness of riparian forest fragments in maintaining stream ecosystem function and diversity in an agriculturally dominated tropical landscape. In particular, these data may provide insight into the longitudinal connectivity of stream ecosystems and the relative importance of local riparian conditions versus cumulative upstream effects in structuring stream communities and food webs.

This issue is extremely important, because in many cases riparian buffers are not continuous along stream channels. In a fragmented landscape with many landowners, management practices with regard to riparian zones are likely to vary widely. Thus, the capacity of riparian forest fragments to restore or maintain stream ecosystem function and diversity is of great interest. Forest fragments along streams may support more diverse benthic communities both through increasing the diversity of food resources available to stream biota and by maintaining more diverse physical habitats. In the future, our research will focus on how the width and longitudinal connectivity of riparian forests influence these factors, as well the implications for aquatic biodiversity.

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## Disciplinary Research Report
## Social Forces Driving Land Use Choices and Their Spatial Characteristics

**Wayde Morse, Steve Hollenhorst, and Dietmar Stoian**

Managing for biodiversity conservation in the agricultural matrix may be as important as managing for conservation in protected areas (McNeely and Scheer 2003). The agricultural matrix influences the effectiveness of reserves, controls landscape connectivity, and is important itself for maintaining biodiversity (Franklin 1993). The agricultural matrix constitutes a complex and dynamic landscape of mixed agricultural and forested areas with multiple owners and objectives. The types and intensities of uses of the agricultural matrix will differentially affect biodiversity (Ricketts 2001), and these uses will be differentially situated across a landscape in accordance with local farmer production and management decision about land use.

To manage the agricultural matrix while balancing both conservation and production needs, it is essential to understand the social forces that are driving production and management decisions about land use (Geist and Lambin 2002). Social forces are the political, economic, institutional, technological and infrastructure, demographic, and cultural factors that influence land use decisions. The objective of this research is to explore and identify the most influential underlying social forces that are driving production and management decisions about land use in the Sarapiquí region of Costa Rica. We aim to establish the linkages of how social forces influence farmer land use decisions that modify tree cover on their farms, and therefore, potential habitat for biodiversity.

We will conduct a two stage sequential qualitative – quantitative analysis to uncover the most influential social forces that are operating in the study area landscape. In stage one we will explore all of the land uses, and social forces that may be influencing farmer decisions about those uses, through expert interviews with government agencies and NGO field staff. Recognizing that not all farmers have the same resources available, categories of farms will be created based on common social force influence. For example, a one hundred hectare beef cattle farm is expected to be influenced by different social forces then a five acre farm where they cultivate black pepper. In stage two, farmer surveys will be conducted using sampling procedures based on the farm categories. Using findings from the expert interviews, the surveys will be designed to identify the social forces that are most influential on production and management decisions about land use from the farmer's perspective. Analysis of these findings will inform us as to *how* the different social forces influence the decision making for the different farm categories.

We will use both the expert and farmer interviews to identify the spatial aspect of these influential social forces and input and analyze them in a computer mapping system. This analysis will reveal spatial locations across a landscape *where* farmer production and land use management decisions are likely to be influenced by different social forces. The farm categories will be ranked as to their compatibility for biodiversity conservation. This information is designed to be the foundation for the stewardship layer of an extended Gap analysis that is the major point of integration with the rest of my IGERT research team.

Activities since April of 2003 for Wayde Morse include moving to Costa Rica and preparation for research to begin. He has taken a class in Spanish at CATIE on 'Rural development and community participation' where he was able to refine some of his research methods. Several of the projects completed for class used the exact methodologies which he plans to use for his research. He has also presented his proposed study to the research director at the Foundation for Sustainable Development of the Central Volcanic Range (FUNDECOR). FUNDECOR will provide his initial source of expert interviews and access to many farmers whom he will interview. They will play an essential role for gaining access to the farmers of this region. Many of the issues addressed in this research were identified as important for conservation management in the region by FUNDECOR. He has also been in contact with many faculty and students at CATIE in an attempt to collaborate and share information with others investigating similar topics. Currently the CATIE projects Fragment, GEF-Silvo-pastoral, and CERBASTAN have been identified as potential areas for collaboration. He will begin his research immediately after the IGERT yearly conference.

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**Disciplinary Research Report**
**The State of Interior Northwest Forest-based Communities:**
**A Rapid Social Assessment of Wallowa County, Oregon; Clearwater County, Idaho; and Lincoln County, Montana**

**Max Nielsen-Pincus and Jo Ellen Force**

## Introduction

The United States Forest Service (USFS) substantially changed its forest management strategy over a decade ago. In 1992 then USFS Chief Dale Robertson issued a directive to forests in the national forest system to adopt ecosystem management as a forest management strategy. Chief Robertson's directive has shifted forest management away from a historic focus on timber production and towards a focus on maintaining ecosystems within their historic range of variability (Greg Kujawa, USFS Kootenai National Forest, personal communication). Although many predictions were made about how changes in timber harvests would affect communities in the Interior Northwest, the actual effects of ecosystem management on communities in the region are unknown. Furthermore, the effects of ecosystem management by the USFS – the region's major landowner – on the management strategies of other landowners, including trends in fragmentation on non-USFS land, are unknown as well. The effects of ecosystem management on the sustainability of local communities and on the trends in forest fragmentation in the region are therefore an import focus for current research.

## Summary of Current Research: Study Area and Methods

During the summer of 2003, we began some exploratory research into the current state of and changes in rural natural resource based communities in the Interior Northwest. Between June 21 and July 16, 2003 we conducted a rapid social assessment of three counties in the Interior Northwest: Wallowa County, Oregon; Clearwater County, Idaho; and Lincoln County, Montana. Although we collected data on the counties as a whole, we focused on three communities, each the county seat: Enterprise, Oregon; Orofino, Idaho; and Libby, Montana. In each community we collected primary qualitative data as well as secondary data from published sources and archived records. The goal of the assessment was to provide an overview of the current state and trends of each community's social structure with respect to natural resource issues. From these assessments we plan to develop and hone further research questions.

Each social assessment collected data from five sources. First, in each community we systematically interviewed between 15 and 20 people in informal interviews, for a total of approximately 50 interviews. We selected informants from quickly derived snowball samples that began with the city clerk. Informants included mayors, county commissioners, school district administrators, USFS personnel, local economic development specialists, local business persons, local NGO executives, and other active community members. Second, we conducted a visual survey of main street business that included occupancy, business type, and spatial context on "Main Street" in each community. Third, we reviewed archived county newspapers, city council records, and county planning records. Fourth, we collected copies of recent relevant published research that were available in each county. Fifth, we retrieved 1990 and 2000 census data for the three largest communities in each county and for county data as well. These five data sources provide us with a diverse set of data to use to make assessments of the current state of the communities in the study area.

### Summary of Current Research: Preliminary Findings

Federal ownership of forest land in each county is high, ranging from approximately 50% to 80%; while population is relatively low in each county, ranging from 7,226 to 18,837. Enterprise, Orofino, and Libby range in population between 1,887 and 3,337. Informants in each study site overwhelmingly perceive their respective communities in a state of decline. This "decline" is represented consistently by a decline in family wage jobs and consistently high unemployment, a decline in earned income, an increase in transfer payments, a decline in school enrollment and budgets, a decline in county budgets and services, a demographic shift towards older and retired residents, and only a modest increase in service sector jobs. Furthermore, informants generally attribute many of these trends to a decreasing supply of federal natural resources, most notably timber. United States Forest Service personnel validate declines in timber supply over the past decade and point out that since the late 1980s Forest Service land management strategies have changed from focusing on maximizing timber production to focusing on restoring ecosystems to their natural range of variability. Forest Service personnel also note that the increase in successful litigation against offered timber sales and service contracts has seriously inhibited the Forest Service's ability to sell timber to local mills and to conduct forest health treatments. Whether the changes in local communities are directly related to ecosystem management is yet unknown; however, we find that local communities perceive ecosystem management and the environmental movement more generally as major contributors to the "decline" of local community.

Each community we visited has experienced a different course of events in the process of natural resource policy change and more general societal changes. The response of each community to these changes has been different as well. The "decline" was portrayed as most severe in Libby, Montana and least severe in Enterprise, Oregon. We find that the outlook of informants – whether positive or negative – appears influenced by the amount of time existing between the present and the most recent major structural change in the community such as a mill closing or a major dispute between the local community and the Forest Service. The greater amount of time between major event and the present, the better the community outlook is in these three communities. The findings presented above are preliminary findings and will require further research and analysis to validate or reject them, or to lead us to more fundamental questions.

### Future Directions

We plan to fully review the data collected this summer in the fall of 2003. Furthermore, from this data we will be developing further and more pointed research questions. For instance: 1) What effects has ecosystem management had on local communities? 2) How has ecosystem management been implemented on forests within the study area? 3) How has the adoption of ecosystem management by the Forest Service affected the actions of other landowners in the study area? We plan to develop methods and instruments to answer questions similar to these as well as others. We are also working to link this disciplinary topic in relevant ways to other disciplines to develop interdisciplinary questions related to the social factors leading to forest fragmentation.

## Disciplinary Research Report
## Forest Fragmentation Effects Upon Biodiversity and the Implications for Conservation Policies in Fragmented Forest Landscapes of the Interior Northwest

**Amy Pocewicz and Penny Morgan**

### Introduction

Ponderosa pine forests have been extensively fragmented by agriculture, timber harvest, and other land uses. Many remaining forest fragments have experienced timber harvesting or home construction within them. Fire suppression has also impacted these forests. Old-growth ponderosa pine forests have been categorized as endangered ecosystems (Noss et al.1995). Fragmentation of this low elevation, biologically rich, structurally diverse and widely distributed ecosystem has great implications for the conservation of biological diversity in the Interior Northwest.

The effects of forest fragmentation have traditionally been studied with a focus on the forest fragments, but it is increasingly apparent that the matrix, those habitat types surrounding fragments, greatly influences their biodiversity patterns and level of isolation. In order to identify conservation priorities and inform policies related to conservation, we need to understand how fragment biodiversity is affected both by forest management and structural variation and their spatial context within the broader landscape. In areas where once continuous forests are now surrounded by a sea of agriculture, roads, and other human infrastructure, the alteration of land uses surrounding forest fragments could greatly soften the impact of ongoing human use on biodiversity.

### Research questions

Two broad research questions will be addressed:
1) How are biodiversity indicators affected by forest fragment size and spatial context?
2) Do these patterns hold across different landscapes in the Interior Northwest?

Question 1 is informed in part by Island Biogeography Theory, which states that large, less isolated fragments will have the higher species richness than small, isolated fragments. Additionally, the quality of the habitat in the matrix affects the migration rate or dispersal between habitat patches. Matrix characteristics can also affect the structural and microclimatic conditions of the fragment and influence its effective size. The term biodiversity indicator is used broadly here to refer to species as well as measures related to ecosystem function.

There are currently four landscapes being considered as study sites. These are located in Latah and Clearwater Counties in Idaho, Wallowa County in Oregon, and Lincoln County in Montana. Differences found between landscapes in Question 2 might relate directly to fragment management and use and landscape biophysical differences and indirectly to the causes of fragmentation. Causes of fragmentation include conversion for agriculture, roads and timber harvesting. Question 2 fits into a broader interdisciplinary framework considering how federal policies and social climate affect biodiversity via their influence upon the causes of fragmentation. Through work with an interdisciplinary team, we hope to provide information useful in developing policies that favor land uses “friendly” to conservation of biodiversity within fragmented forest landscapes.

## Current activities

Our preliminary study is in progress to address the following research questions: 1) Do plant species composition and diversity in forest fragments relate to fragment size or landscape context?; 2) Are differences in plant composition and diversity better explained by other variables, such as canopy closure and microclimate, than by fragment size or landscape context?; 3) How many sample plots are necessary to capture within-fragment variation and adequately address the preceding questions?

The study area is the predominantly agricultural landscape of the Palouse in Latah County, Idaho. Only 11% of the original ponderosa pine forest is estimated to remain in Latah County (Johnson 1999). Almost all fragments have experienced some logging of the large trees; few have snags or large-diameter trees with interlocking crowns. We will focus on ponderosa pine forest, which typically belongs to the Douglas-fir *(Pseudotsuga menziesii)* /ninebark (*Physocarpus malvaceus*) habitat type. These are low elevation, warm, dry forest sites important to many bird and butterfly species.

Forest fragments are being selected to encompass a range of sizes, falling into two broad categories: 1-5 ha and >10 ha. Small fragments are either surrounded by perennial vegetation cover (i.e. Conservation Reserve Program) or agricultural crops. Fragments are being roughly stratified by distance to continuous forest. Landscape spatial context will also be measured by the amount of forest cover within a given radius of the fragment. Only fragments that are completely isolated from other forest and with no buildings within them are being used. Potential fragments are located on 1998 Digital Orthophotos, and those meeting the requirements outlined above are sampled if landowner permission is granted. Eight to 12 sites will be sampled by the end of August 2003, including two continuous forest sites. Three pairs of edge and interior plots are being measured within each fragment. The following vegetation data are being collected at each plot: percent cover by species of forbs, grasses and shrubs, basal area by species for large trees, small trees, and canopy closure. The data will be analyzed this fall, and the results will help to refine future questions and sampling.

We are also evaluating additional indicators of biodiversity. We are exploring the usefulness and feasibility of measuring butterfly and moth species richness and abundance. This is being done through literature review and with the assistance of a local expert. Birds are also being considered, and an experienced birder may be hired to do surveys in spring 2004. We are also interested in incorporating a functional indicator related to forest ecosystem processes, such as tree water use efficiency or nutrient uptake. We will visit the other landscapes in August and September, which is important for designing the full research study plan and developing the interdisciplinary questions.

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**Disciplinary Research Plan**
**Fate and Transport of Pesticide Residues in the Talamanca Region of Costa Rica**

**Beth Polidoro, Matthew Morra, and Eduardo Somarriba**

Bananas are one of Costa Rica's most important exports, and many banana plantations depend on intensive use of several types of pesticides to improve productivity. One third of the total pesticides volume imported into Costa Rica is used on banana plantations (Castillo et al. 1997). Although pesticide use is generally much higher in commercial banana plantations compared to small holdings, knowledge of safe-practices is not widespread, and regulatory infrastructure is underdeveloped or not adequately enforced. In the Talamanca region, the aerial application of pesticides, unregulated or poorly managed pesticide application, and the clearing of riparian vegetation combined with over 6,000 mm of annual rainfall creates a high risk for pesticide contamination of aquatic resources. Pesticides and their degradation products can be redistributed by atmospheric drift from aerial application or with precipitation from volatilization. Dissolved pesticides in the soil or aquatic environment can be leached and enter groundwater resources, while pesticides sorbed to soil sediments can enter rivers by erosion. Once in the river system, suspended sediments carrying sorbed pesticides will eventually accumulate in low-velocity depositional zones such as streambanks, wetlands, mangroves, and estuaries. High concentrations of pesticides in regional water resources are a threat to human health and aquatic organisms. However, few studies regarding environmental distribution, toxic effects on aquatic organisms, human exposure or general impact on ecosystems have been undertaken in tropical areas.

Baseline study objective: To determine the presence, type and concentration of pesticides in water and sediment samples in the Bribri-Cabécar reserve.
1. Which rivers in the reserve contain pesticides in the water column or in river sediments?
2. What types of pesticides are present and in what concentrations?
3. What are the likely sources of pesticides in the river water and sediments?

Large concentrations of commercial banana plantations in the Talamanca region are centered in the cleared lowlands of the Rio Estrella, which feeds into the Atlantic Ocean through an estuary and influences nearby Parque National Cahuita. Previous studies (Castillo et al. 1997) on the Rio Estrella found several types of pesticides in river and river sediment samples with concentrations above that known to cause damage to fish. Water samples from nearby drinking water sources had concentrations of several toxic pesticides well over the established European safe drinking water standard. By contrast, the Bribri-Cabécar indigenous reserve, located in a separate watershed adjacent to the Rio Estrella valley, is an important forested area of organic cacao, banana and plantain production. The reserve is comprised mainly of independent small-scale farmers who rely on many types of agroforestry to maintain crop productivity. Several indigenous organizations (ANAI, APPTA, ADITBRI, ADITICA) work to certify and maintain sustainable organic production, as well as to promote and improve flora and fauna biodiversity and conservation in the reserve. Maintaining water quality in the reserve is also a priority as many inhabitants use the rivers for bathing, swimming, and sometimes drinking water. There is specific concern that pesticides may be present in some rivers as a result of past or present application within the reserve, or from atmospheric drift due to volatilization and aerial application in commercial banana plantations in the adjacent Rio Estrella valley. Under the guidance of ANAI and APPTA, a baseline study of the major rivers, all of which converge into the Rio Sixaola, is needed to determine the type, concentration and potential sources of pesticides present in the reserve. Initial testing of river water, rainwater, and river sediments would require a preliminary survey of past application history, current pesticide application, and potential degradation products in order to identify pesticide types and their possible sources.

Extended research objective: To understand and identify the principal factors that influence pesticide transport, deposition, and toxicity within the Bribri-Cabécar reserve.
1. To what extent are pesticides accumulating in areas of low water velocity, such as streambanks, wetlands, and marshes?
2. Do concentration levels of pesticides in river water and deposited sediments pose a threat to humans or aquatic fauna?
3. Do forested riparian areas influence the transport of pesticides compared to unforested riparian areas?
4. Are there differences in pesticide distribution, degradation and toxicity in tropical areas compared to temperate areas?

As suspended sediments are deposited in areas of low water velocity, wetlands, marshes or floodplain areas that are hydrologically connected to contaminated rivers could be sampled to determine if settled sediments are a significant source of toxic pesticide accumulation. With known concentrations of pesticides and degradation products in reserve river water and sediments, as well as in low-velocity depositional zones such as wetlands, biological toxicity tests could be conducted in the laboratory to determine pesticide tolerance levels on selected freshwater species present (fish, bivalves or macroinvertebrates). Previous studies indicate that certain species of Ephemeroptera and Tricoptera may be the most sensitive benthic macroinvertebrates to pesticide exposure (Castillo et al. 2000). Results from laboratory toxicity tests would need to be verified in the field to determine their usefulness as indicator species for toxic concentrations of specific pesticides. As forested riparian areas can act as buffers against sedimentation and pesticide loading in streams by filtering agricultural runoff and erosion, extended research could examine differences in pesticide transport through forested areas versus through unforested or agriculturally cleared lands. Further research is also needed to understand the environmental behavior of pesticides in tropical versus temperate climates. Previous studies (Castillo et al. 1997) indicate that pesticide degradation as well as toxicity and bioconcentration may increase in tropical conditions.

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## Disciplinary Research Plan
## Bee Communities in a Coffee Dominated Landscape

**Mariangie Ramos, Nilsa A. Bosque-Pérez, and Luko Hilje**

Pollination systems are an important form of biodiversity, considering that they involve 100 million-year old co-evolutionary relationships between the world's dominant flora, flowering plants, and dominant fauna, insects, in addition to some groups of vertebrates (Kevan 1999). Habitat fragmentation has been suggested as a possible force disrupting global pollination systems (Kremen and Ricketts 2000). Pollination limitation results in lower plant fitness by reducing mating opportunities and seed output (Aizen and Feinsinger 1994). Declines in pollinator communities increase homozygosity (Shapcott 1998) and may lead to the extinction or reduced genetic variability of plant species (Allen-Wardell et al. 1998, Buchmann and Nabhan 1996). Also, animal pollination (mainly by bees) is a crucial process for the productivity of many important crops (Kremen and Ricketts 2000).

Bees (Apoidea) are the most important pollinators in temperate areas and key pollinators in the continental lowland tropics (Cane 2001). They have to travel frequently between forest fragments to forage (Murren 2002). However, their movement and use of the agricultural matrix could be reduced by management practices in farms like pesticide use and diversity of farm plant species (Kevan 1999). This may decrease pollination services provided by bees to agricultural areas. For example, in watermelon plantations in California, only organic farms near natural habitat fragments received full pollination services from native bee communities (Kremen et al. 2002). Due to the current declines in the traditionally managed honey bee, *Apis mellifera* (Allen-Wardell et al. 1998), pollination by native bees may become more important in the future.

Although coffee (*Coffea arabica*) is self-fertile, it can benefit from pollination by bees (Roubik 2002, Badilla and Ramirez 1991). Coffee is major crop in many tropical areas because of its high economic importance, being only second to petroleum as an international commodity (FAOSTAT-online http://apps.fao.org). Management practices in coffee agroecosystems may affect the capacity of these agroecosystems to sustain biodiversity (Moguel and Toledo 1999, Perfecto et al. 1996). We are interested in determining the effects of bee floral visitors on coffee yield, and examining the mechanisms for these effects. In addition, we will focus on the effects of remnant forest fragment distance and agricultural management practices on bee diversity and abundance in a coffee dominated landscape. To achieve this, two specific questions will be asked. (1) What is the effect of distance to remnant forest fragments on bee species richness and abundance on coffee plantations? (2) What are the effects of farm floral resources (including coffee plants, weeds and shade trees) on farm bee diversity and abundance throughout the year?

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## Disciplinary Research Plan
## Understanding the Effects of Forest Loss and Fragmentation on Frugivorous Birds: An Integrated Approach

**Dina Roberts, E. O. Garton, and Celia Harvey**

### Research Summary

The proposed dissertation research comprises two components as follows: 1. Examining the effects of forest loss and fragmentation on frugivorous birds, and 2. Using frugivorous birds as focal species for understanding habitat associations and predicting species occurrences in complex tropical forests. For the first component, we will address the question of how forest fragmentation affects movement and survival of a Nearctic-Neotropical migratory songbird, the Wood Thrush (*Hylocichla mustelina*). This species has shown steady declines on the breeding grounds in North America and little information currently exists about its survival on the wintering grounds. To fully understand what limits a population, it is critical to study habitat needs at all phases of the annual lifecycle. Therefore, this study will fill a gap in knowledge about over-winter survival and habitat use between continuous forest (La Selva and La Tirimbina) and forest fragments (FUNDECOR and FRAGMENTS). If additional research funds become available, we will incorporate habitat use and movement of a canopy frugivorous bird, such as the Keel-billed Toucan (*Rampastos sulfuratus*), to contrast with data collected on the Wood Thrush, an understory frugivore.

For the interdisciplinary component, we will be combining data collected on canopy frugivorous bird distributions and habitat associations with new vegetation classes derived by Steve Sesnie as part of his doctoral research. We will construct wildlife habitat models for focal bird species. Wayde Morse will simultaneously build a social compatibility map, otherwise known as a stewardship layer for a Gap analysis. Once all data are collected and analyzed, we will combine the layers within a Gap analysis framework. Ultimately, we will produce a map and a database of priority areas that will be presented to local and national NGO's and government agencies interested in protection of biodiversity or the continuation of environmental service payments within the Sarapiquí region of Costa Rica. We expect to begin collecting data on Wood Thrush in December 2003.

# Disciplinary Research Report
# Earthworm Survey in the Palouse Region, Idaho and in Coffee Plantations, Costa Rica

**Yaniria Sánchez-de León and Jodi Johnson-Maynard**

Earthworm communities are important members of the soil macrofauna (e.g. Edwards and Bohlen 1996). Earthworm diversity has been related to critical soil ecosystem functions such as decomposition, nutrient cycling, and maintenance of soil structure (Groffman and Bohlen 1999, Lavelle 2002). Earthworm species are classified in three main ecological groups: epigeic (litter dwellers), anecic (soil dwellers feeding on litter) and endogeic (soil dwellers) earthworms. Each of these groups has a different effect on soil. For example, anecic species may increase the disappearance and incorporation of surface litter to mineral soil and the macropores created by their burrows affect the moving of water to lower soil depths (Blair et al. 1995). However, some endogeic species have a significant effect in the microbial activity of ingested soil (Blair et al. 1995).

This report on disciplinary activities contains our research activities of this summer season. It contains a section on research in Palouse region and a section in coffee plantations with different management practices at CATIE experimental fields. The results presented are preliminary given that these are ongoing projects. We collected baseline data necessary for our research on earthworm biodiversity and their effects on nutrient cycling. We focused our activities on collecting data of earthworm diversity, density and biomass in three different land uses within the Palouse region. For research in Costa Rica, we collected data on earthworm diversity, density and biomass in sun and shade-coffee plantations at CATIE experimental fields.

## Research in Idaho

We concentrated this study on Palouse prairie remnants, Conservation Reserve Program (CRP) lands and ponderosa pine forests. Earthworm community structure is unknown for prairie remnants and Conservation Reserve Program (CRP) lands. Our research question was: Is earthworm diversity in prairie, CRP and ponderosa pine forests different? We hypothesized that earthworm diversity will be higher in prairie remnants than in ponderosa pine forests and will be less in CRP due to higher plant and habitat diversity and lower disturbance in prairies and ponderosa pine forests.

Three research sites were located in the Palouse region in northern Idaho and each of the sites had a prairie remnant, a CRP and a ponderosa pine forest adjacent to each other. We collected earthworms from six 25 x 25cm pits that were excavated manually to a depth of 30 cm at each of the study sites. Earthworms were counted and fresh weight was recorded. We identified earthworm species using the taxonomic key by Schewert (1990). Soil and litter samples were also collected for carbon and nitrogen analysis.

We only found two earthworm species: *Aporrectodea trapezoides* and *Lumbricus* sp. Prairies were dominated exclusively by *A. trapezoides*. Mean earthworm density was 67 (individuals/$m^2$) in prairie remnants, 107 (individuals/$m^2$) in CRP lands and 47 in ponderosa pine forests. Mean earthworm fresh weight was 37 ($g/m^2$) in Prairies, 45 ($g/m^2$) in CRP lands and 25 ($g/m^2$) in ponderosa pine forests.

Earthworm diversity was not higher in Prairie remnants than in other land uses studied. Native earthworm species of our study areas were probably eradicated by changes in habitat or by competition with exotic species. Other soil factors, such as depth, pH or carbon and nutrients concentration in these sites may explain earthworm density or biomass distribution in these areas.

**Research in Costa Rica**

We concentrated this study on measuring earthworm diversity, density and biomass in sun and shade coffee plantations located at CATIE experimental fields. Our research question was: How does earthworm diversity change with coffee management practices? We hypothesized that earthworm diversity will be greater in shade coffee plantations than in sun coffee plantations, because shade coffee plantations will provide more habitat for earthworms than sun coffee plantations.

The coffee plantations were located at CATIE experimental fields. We selected two sun coffee managements: conventional (same management as in commercial sun coffee fields) and half conventional (half of the inputs on conventional management). For shade coffee, we had fields with the tree *Erythrina poeppigiana* and fields with the tree *Terminalia amazonia*. Each of these shade coffee fields had three different management practices: conventional (same management as in commercial shade coffee fields), half conventional (half of the inputs on conventional shade coffee management) and organic shade coffee. We had three replicates of each management for sun and shade coffee plantations. We collected earthworms from five 25 x 25cm pits that were excavated manually to a depth of 10 cm at each of the study sites. Earthworms were counted and fresh weight was recorded.

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**Disciplinary Research Report**
**The Influence of Edge Effects on Carbon Storage and Forest Structure: An Investigation of Pattern and Process**

**Jessica Schedlbauer, Kathleen Kavanagh, and Bryan Finegan**

## Research Summary

The anthropogenic fragmentation of forest ecosystems leads to the development of edge effects which can result in forest structural changes and altered patterns of carbon storage. These changes may decrease available habitat for forest-interior plant and animal species, and alter ecosystem function. Edge effects will be quantified in ten to twelve sustainably managed primary forests in the Sarapiquí region of Costa Rica. Specifically, measures of aboveground carbon storage in trees, soil carbon storage, and forest structure will be made in forest fragments. Additionally, the roles of light and water use efficiency in the maintenance of edge effects will be evaluated using stable carbon isotopes. Ceptometer measurements and hemispherical photographs will be used to examine forest structure, leaf area index, and light in the forest understory. Data collected in forest fragments will be compared with data from contiguous forest to test the hypothesis that interior areas of forest fragments exhibit characteristics similar to those of contiguous forest. This research will also be used to evaluate the hypothesis that forest edges in the Sarapiquí region seal with vegetation and stabilize with time rather than approach a hyper-disturbed state characterized by a receding forest edge.

## Study Site Selection

With the aid of an employee from Fundación para el Desarrollo de la Cordillera Volcánica Central (FUNDECOR) time was spent in the field examining and identifying potential field sites. To date four new sites that contain primary forest fragments have been identified. All sites are located on privately owned farms whose owners have signed an agreement to work with FUNDECOR to protect and/or sustainably manage their forested land area. In most cases forest fragments have been subject to sustainable timber harvesting activities under the Forest Stewardship Council's guidelines. Additional criterion for the selection of study sites included the presence of a forest-pasture or forest-road-pasture border that was at least twenty years old. All sites with streams or swamps at the forest margin were eliminated as potential sites to avoid the variation that would be introduced by the presence of riparian vegetation.

Of the ten to twelve forest fragments that will be used in this study, five will be drawn from an existing set of permanent sample plots used in a previous study of edge effects and tree species composition (Forero and Finegan, *unpublished data*). These five sites, Rojomaca, Ladrillera 1, Ladrillera 3, Paniagua, and Selva Verde, are located primarily within the elevation range of 30 to 80 m asl. Due to limitations in the number of sites that fit the criteria listed above, all of the newly selected study sites are located at higher elevations of approximately 200 to 300 m asl. To facilitate comparisons between data collected in forest fragments and data from continuous forest, we are working toward establishing permission to work in areas with contiguous forest (primary forest >1 km from the forest edge). These sites include the La Selva Biological Station of the Organization for Tropical Studies and Braulio Carrillo National Park. Sites within La

Selva will be used as a baseline for the sites at lower elevation, while sites within Braulio Carrillo will be compared with higher elevation study sites.

**Preliminary Data Collection**

During June and July 2003 two new transects were created within Rojomaca to examine their relative utility in relation to the site's permanent sample plots. The permanent sample plots were established by Forero and Finegan in 2001. Three permanent 20×100 m plots currently exist at 0, 150, and 300 m from the forest edge. There are three replicates of this plot design within Rojomaca. The new transect design is composed of continuous 25×25 m plots that extend from 0 to 325 m into the forest interior. To date, a preliminary data set has been collected along the two newly created transects at Rojomaca. These data will be analyzed during the next several months and will be compared with data previously collected at the permanent sample plots. This analysis will help to determine an optimal plot size and will refine future data collection set to commence in March 2004.

Within each plot the diameter at breast height (dbh) (1.3 m) of all trees and palms >10 cm dbh were recorded. Diameter measurements were made above stilt roots or buttresses when present. Additionally, species (when known), crown position, and crown shape was recorded for each tree measured. Two species, *Pentaclethra macroloba*, a canopy tree, and *Socratea exorrhiza*, a subcanopy palm, were regularly noted and identified because their foliage will be collected in August 2003 for stable carbon isotope analysis. *Pentaclethra macroloba* is the dominant tree species in the Sarapiquí region and *Socratea exorrhiza* is a common subcanopy palm also found throughout the region. Both species were present in the majority of plots measured for this study. Foliage will be gathered from two to three individuals of each species within each plot. Samples will be dried and sent to the Idaho Stable Isotopes Laboratory, University of Idaho, Moscow, ID, USA for analysis with mass spectrometry.

In July 2003 leaf area index (LAI) and percent open sky were measured in newly created plots to quantify canopy structure along edge to interior gradients. Both a ceptometer and hemispherical photographs were used to collect data that will be used to calculate LAI within each plot. The relative utility of each method will be evaluated to determine the most appropriate methodology for further data collection. In addition to LAI, the hemispherical photographs will be used to measure gap fraction.

**Disciplinary Research Plan**
**Habitat-Based Conservation Planning in Costa Rica: Predicting the Effects of Fragmentation on the Long-Term Persistence of Area-Sensitive Species**

**G. Jan Schipper and J. Michael Scott**

Within the disciplinary framework of the NSF-IGERT program at the University of Idaho, we will examine the effectiveness of the current Costa Rican reserve system in protecting long-term viable populations of area and habitat sensitive mammals. One primary goal will be to examine the relative porosity of land-use types for the dispersal of metapopulations between protected areas, thus identifying potential source and sink populations. We will determine which land-use types outside of reserves are suitable for the dispersal of species with either large area requirements or narrow habitat constraints. By designing and validating a suitability index of remaining habitat for individual species across a landscape, we will attempt to improve both the science and the policy of habitat-based conservation planning in Costa Rica.

At the broadest scale, accurate vertebrate distribution models in the Neotropics and elsewhere are useful in determining potential species occurrences (Ron 2000, Boitani et al. 1999). This information is important for evaluating if a reserve system captures the assumed richness and diversity of particular taxa. The identification of gaps in protection and in habitat representation have been developed over multiple scales and resolutions (Scott et al. 1993, Soulé and Terborgh 1999). Methods for spatial planning of habitat conservation have also been well developed in recent years; yet putting the science into practice remains a challenge (Groves et al. 2002, Abbitt et al. 2000, Scott et al. 2001, Noss et al. 1997, Noss and Cooperrider 1994). While quantifying species diversity and richness at a broad scale can be effective for national or bioregional reserve design, monitoring and evaluation of individuals and metapopulations must be considered at the landscape scale. In other words, there is a spatial hierarchy at which measures of success can be quantified.

Modeling species occurrence and the distribution of remaining habitat are the first steps in understanding spatial constraints of a given country or landscape. The next step is to test and validate these models in the field. Because sampling all species is impossible in the scope of this project, selected species will be used to test some of the basic assumptions. In choosing an indicator species or group of species, it is important to examine the ecological role of the species and specific spatial and habitat constraints. In the scope of this study, mammals represent an indicative group at the scale of reserve effectiveness. Mammals with broad habitat and large-area requirements such as jaguar (*Panthera onca*) and tapir (*Tapirus bairdii*) will likely not persist over the long term if populations are confined to existing reserves, unless land-use types outside reserves are permeable or connected through habitat corridors. On the other hand, mammals with narrow habitat constraints (such as arboreal specialists) or narrow distributions (regional endemics) are more likely to be confined to forest fragments and populations are thus at the mercy of the land-use history within their range of occurrence. In many cases, little is known about dispersal constrains to arboreal mammals and there is a great need to examine critical thresholds in their responses to changing landscape patterns.

Current protected area systems in Costa Rica are largely discontinuous and areas between reserves have been almost entirely converted to agriculture and urban development. There are currently over 30 conservation corridor projects proposed in Costa Rica (Boza, M, pers. comm.), yet no formal vision for how to prioritize implementation and management exists. If viable populations of species are to be maintained, then better understanding of both the porosity and barriers to dispersal of these species within the predominantly human dominated landscape is necessary. This project seeks to work with the local government organizations and international NGO's from the inception, both to streamline with current projects which are being developed as well influence the policy making and legislation surrounding the design and management of conservation areas.

In summary, we seek to develop and refine habitat suitability models for a suite of mammals, validate the models with field techniques (camera trapping) to confirm presence, and potentially radio-collar individuals to examine site specific habitat associations. This information will be developed into a decision-support system to aid local planners and stakeholders in improving conservation measures both inside and outside of protected areas.

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**Disciplinary Research Report**
# A Geospatial Data Integration Framework for Mapping and Monitoring Tropical Landscape Diversity

**Steve Sesnie, Paul Gessler, and Lucio Pedroni**

## Research Summary

### Landscape Diversity and Mapping

Forest loss and fragmentation is the single largest threat to maintaining current levels of biodiversity in Latin America, yet the impact on specific habitats remains unclear (Matthews et al. 2000). Complex tropical landscapes and land changes are often broadly defined by "forest" and "non-forest" categories (Kleinn et al. 2001). Large area information on the diversity and distribution of land cover types is frequently lacking due to limited field data and inaccessibility (Foody and Cutler 2003). However, most tropical land areas are now covered by extensive Landsat image archives and other spatially referenced data. Our research focuses on validating a remote sensing based land classification framework that integrates calibrated, low cost, multitemporal, multispectral satellite imagery with other geographic information to enhance precision and accuracy of mapped vegetation types. A Potential Vegetation Type (PVT) modeling framework will be tested within a ±2,500 $km^2$ pilot study area in Costa Rica along an ecological gradient between sea level and 3000 meters elevation. Dominant and indicator tree species will be used to identify forest composition classes that are distinct from one another. A PVT model integrates biophysical information such as topographic features derived from a Digital Elevation Model (DEM) and other spatially referenced data, such as soil types, to explain variation in vegetation composition (Keane et al. 2001). Multiple image dates will be used to classify secondary forest and agricultural cover types difficult to detect using a single image date. Once validated, these methods will provide a readily updatable classification system to monitor frequent disturbances important for biodiversity.

### Monitoring Conservation Policy and Programs

A time series of classified images will be used to address research questions regarding sustainable forest management policies and incentive programs. The efficacy of the Costa Rican 1996 Forestry Law to prevent further forest loss through environmental service payments and certified sustainable forest management are currently not known (Chromitz et al. 1999). It is suspected that areas legally classified as forest land use are gradually converted to agroforestry systems by illegal tree harvesting that has sharply increased since the 1996 law (MINAE 2003). We hypothesize that the mean patch size of forest remnants has significantly decreased due to understory clearing and then conversion to pasture with trees since the 1996 Forestry Law. Further, remnant trees within agroforestry systems have potentially decreased significantly since 1996 as permits for tree harvesting in pastures are now easier to obtain. Repeatable and low cost procedures integrating geospatial information to map and monitor landscape diversity are essential for estimating the large-scale impacts of conservation policy and implementation programs. Land change and classification methods validated through this research will be combined with complementary studies examining wildlife habitat use and farmer land use decision making for integrated analyses.

**Research Progress**

Disciplinary aspects of this research are outlined in a funding proposal submitted to the Canon National Parks Science Scholars Program May of 2003. Additional funding will be required for the field verification component of this study and to complete all dissertation requirements in a minimum of 4 years. Future research will potentially compare the classification model for Costa Rica with a prototype model for Glacier National Park dependent upon Canon funding. Both areas are key biological corridors for wildlife movement where maintaining connections between habitats is considered important for species viability.

Contact with collaborators at the national level is currently being pursued and a summary of this research will be presented August 5$^{th}$ and 6$^{th}$ at the "Workshop for geographic information resources in the San Juan – La Selva Biological Corridor" at the La Selva Biological Station in Costa Rica. The recent NASA/JPL CARTA mission in Costa Rica has obtained imagery with the new MASTER sensor and will be discussed during the workshop. These images provide a wider spectral and dynamic range alternative to the use of Landsat TM and ETM+ imagery. Newly acquired data from the MASTER sensor will provide a basis for comparison between image types of differing spectral resolutions for classifying land cover types using the PVT framework.

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**Internship Report**
**Effect of Tillage on Abundance and Activity of the Pea Leaf Weevil**
**(*Sitona lineatus* L.)**

**Ruth Dahlquist, Nilsa A. Bosque-Pérez, Dennis Schotzko, Tim Hatten, and Sanford Eigenbrode**

The pea leaf weevil (*Sitona lineatus* L.) is an important pest on peas in the northwestern United States (Schotzko and Quisenberry 1999). Adults migrate from alfalfa fields into pea fields in the spring, where they feed on foliage leaving characteristic notches, and reproduce (Williams et al. 1998). Growers spray if weevil numbers are high. An ongoing study has found that pea leaf weevils sampled in pitfall traps are over three times more abundant in CT than in NT fields early in the season (Hatten unpublished). NT pea farmers observe less damage from the pea leaf weevil compared to CT, but no data exist to support this claim (Hatten pers. obs.). Lower levels of pea leaf weevil damage might reduce costs associated with pesticide use, providing an incentive for farmers to adopt NT methods more widely and thus reduce soil erosion.

The observed reduction in pea leaf weevil abundance in NT fields could be due to preferential colonization of CT fields after seedlings emerge, reduced activity due to residue in NT fields, or increased mortality from predation in NT fields. To evaluate colonization, linear foot soil samples for absolute abundance of weevils (Schotzko and Quisenberry 1999) and damage on seedlings were taken in plots of both tillage types at the University of Idaho Kambitsch Farm on June 2, 2003, as soon as damage was observed. Samples were taken from four replications each of CT and NT (15x19 m plots), with ten samples per replication. To evaluate activity, two mark-recapture experiments were conducted. Marked weevils were released into 0.17 $m^3$ cages and collected in pitfall traps in both tillage types, with three replications of NT and CT (Southwood and Henderson 2000). The first experiment used dry pitfall traps with a petroleum jelly barrier to keep the weevils in, and the second experiment used pitfall traps with antifreeze.

Pea leaf weevils were significantly more abundant in CT plots, with a mean of 0.42 weevils per plot vs. a mean of 0.18 weevils per plot in NT ($P = 0.03$). Weevil damage was significantly greater in CT plots, with a mean of 1.38 notches per node vs. 0.53 notches per node in NT plots ($P = 0.006$). Weevil activity was not significantly different between tillage treatments. In the first mark-recapture experiment, 0.36 weevils per day were collected on average in CT vs. 0.27 in NT ($P = 0.89$). In the second mark-recapture experiment using antifreeze in the traps, the total number of weevils captured over the course of the experiment was calculated. A mean of 10.3 weevils was captured in CT, compared to 12 in NT, a non-significant difference.

The results of this study indicate that the pea leaf weevil is indeed less abundant in no-till pea fields in the early stages of pea growth, and that differences found between tillage treatments using pitfall traps were not biased by differential activity.

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**Internship Report**
**Social Assessment for the Idaho Panhandle National Forests:**
**Prescribed Fire and Forest Health**

**Wayde Morse, Julia Parker, and J.D. Wulfhorst**

The authors designed and implemented the social assessment to be used by the Idaho Panhandle National Forests for their new forest management plan. A social assessment is a report designed to evaluate public perceptions, values, attitudes, community characteristics and other social factors that affect community and Forest Service relations (Parker et al. 2002). Our assessment focused on the state of the local communities, local perceptions of forest resource management, and the relationship between communities and the Forest Service.

The Idaho Panhandle National Forests cover over 2.5 million acres of northern Idaho and represents over half of the forest cover in the region. The area has a number of small towns dispersed throughout the region. For many of these towns, forest production (logging and mill work) has been the core of both their economic and cultural heritage. The only major metropolitan area in the region is Spokane, Washington. There are, however, two areas of both economic and population growth: Coeur d'Alene and Sandpoint.

We used qualitative methods to gather data for the social assessment. We completed 116 in-depth interviews. These interviews were designed with open-ended questions to explore the interviewee's thoughts and ideas without being limited to the response categories of a typical survey. Probing questions were designed to pursue more specific topics of interest to the researchers as they emerged during the interview. All authors participated in the design of the interview guide and probing questions.

**Practical application of the internship for Wayde Morse**

Through this process Wayde learned much about using exploratory qualitative interview techniques that he will apply to his personal research. For example, he learned that for his personal interview style, he needs more structure in the interview process. Because of this lesson, and the fact that he will be conducting interviews for his project in his second language, Wayde has designed a structured format for his open-ended and probing questions. He has also designed a whole preliminary stage of the project (the expert interviews) to identify useful and intelligent probing questions.

As part of the internship, Wayde transcribed a number of the interviews conducted both by himself and other interviewers. This was an important exercise both to understand the time it takes to conduct this process and because in typing a transcription it is easy to identify where the interview 'could have gone' with a different set of probing questions. For his personal research project, Wayde plans to do the transcription of each interview before he initiates the next interview. In this manner, he can adjust and improve the exploratory interview guide before he conducts the next interview (Miles and Huberman 1994).

The internship also provided Wayde with the opportunity to learn how to use the NUD*IST(N5) (QSR 2000) software package for textual data analysis. This program allows one to manage and analyze large amounts of textual data. To reduce the huge amounts of textual data into a manageable form, codes are attached to sections of the text to identify the topic or theme being addressed by that section of the interview. All of the 116 transcribed interviews were coded in this manner and entered into the software database. With this information, one can conduct searches on specific codes and identify relations or themes within the codes. For example, one could search for all the instances that prescribed fire was mentioned, and then search again for all the times it was mentioned in relation to forest health. In this manner one can identify all the text that related specifically to these two coded topics. This facilitates the process of identifying relative text to be used in the analysis of the interviews.

**Journal article**

The example given above is exactly what the authors did to organize the textual information used to write an article that was submitted for a special issue in the journal Society and Natural Resources relating public perceptions/attitudes about prescribed fire to individual's definitions of forest health. For all authors, this was a useful exercise in learning how to use the textual database in writing a journal article. The article was recently submitted and we will not have information about its acceptance for several months. The following is the abstract from the submitted article:

Forest health is a metaphor often used by scientists, managers and the public to describe the desired condition for our National Forests. Prescribed fire is one of the management tools employed by the Forest Service to maintain or create a healthy forest. This article describes and analyzes an array of individual attitudes toward prescribed fire management. Information for this study was gathered as part of the social assessment conducted for the Idaho Panhandle National Forests' new management plan using a case study analysis. We explore local public perceptions of past and future resource management with regard to specific questions of individual perceptions about prescribed fire management. Attitudes toward prescribed fire were found to be intimately connected to individuals' perceptions of how best to achieve forest health, and contextually dependent on the types and locations of specific prescribed fire applications (Morse et al. 2003).

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## Internship Report
## Pollination Effectiveness of Floral Visitors of *Geranium viscosissimum*

**Mariangie Ramos, Nilsa A. Bosque-Pérez, Olle Pellmyr, and Sanford Eigenbrode**

Habitat fragmentation has been suggested as a possible force disrupting global pollination systems. Pollination limitation results in lower plant fitness by reducing mating opportunities and seed output. Declines in pollinator communities increase homozygosity and may lead to the extinction or reduced genetic variability of plant species. The Palouse prairie is a highly fragmented ecosystem (having 99.9% of it converted or developed), and its plant-pollinator interactions may be disrupted. For example, sticky geranium, *Geranium viscosissimum*, has lower seed set in small fragments than in large fragments, and abundance of its large body sized floral visitors is lower on small fragments. However, the importance of floral visitors for the reproduction of *G. viscosissimum* is unknown. For other *Geranium* species, seed production is pollinator-limited (*G. maculatum*) and larger floral visitors are the most effective pollinators (*G. thunbergii*). Determining the importance of the floral visitors of *G. viscosissimum* is necessary to better understand the effects of habitat fragmentation on this plant species. In this study, we examined the pollination effectiveness of two of the most common floral visitors of *G. viscosissimum* that reflect the range of visitor body sizes (6mm and 11mm). We conducted the study at the Kramer prairie remnant, located near Wawawai and Rim Roads, Whitman Co., Washington. We measured pollination efficiency of two *Andrena* (Apoidea: Andrenidae) species (6mm, n = 34 and 11mm, n = 14) by counting the number of pollen grains deposited on the stigma. Flowers with closed stigmas where selected randomly emasculated and bagged. The next day, the bag was removed and the virgin flowers were allowed to be visited by selected visitors. Visitors were identified by sight. After a single visit, flowers were collected and taken to the laboratory, where pollen deposited on the stigma was determined by squashing the stigma with warm glycerine jelly tinted with basic fuchsin and counting the grains under a compound microscope (10xx). Negative controls (n = 35) were flowers that were not allowed to be visited and positive controls (n = 35) were randomly selected flowers to which no treatment was applied. ANOVA was used to determine differences on number of pollen grains deposited. The number of pollen grains deposited did not differ significantly among treatments ($F = 1.68$, $P = 0.1750$). Neither *Andrena* species appear to contribute significantly to the reproduction of *G. viscosissimum*. Further studies will be conducted next year to continue examining the pollination effectiveness of these species and two more (to expand the size and visitor range), including their effect on seed set. Pollinator behavior, including time of visit and activity on flower, will be recorded. Breeding experiments will be performed to determine if *G. viscosissimum* is self-fertile.

## Internship Report
## A Geospatial Comparison of Breeding Habitat Models for the Flammulated Owl (*Otus flammeolus*): An Integrated Approach

**Steven Sesnie, Dina Roberts, Leona Svancara, Mike Scott, Paul Gessler, and Oz Garton**

A variety of habitat models are currently available to the scientist or manager interested in understanding the distribution of single or multiple species (Morrison et al. 1998). Gap analysis is one method for assessing conservation status of biodiversity that is increasingly used in temperate zone conservation planning, and could potentially benefit conservation planners in tropical countries (Prendergast et al. 1999). Gap uses a geographic information system (GIS) to integrate spatially referenced land cover data, species occurrence and habitat information, with land conservation status to map potential species distributions and vulnerability (Scott et al. 2002). These methods are quickly evolving to assess multiple species habitats and biodiversity levels as data and applications are constantly updated. However, mapped habitats are infrequently compared with actual species occurrences to assess these methods.

To study congruence between habitat models and species occurrence, we compared three separate breeding habitat models for the Flammulated Owl (*Otus flammeolus*), a Nearctic-Neotropical migrant that breeds throughout the Western US and is thought to winter from Mexico to Guatemala (McCallum 1994). This species was recently listed by the US Fish and Wildlife Service as a species of conservation concern (http://migratorybirds.fws.gov/). Extensive logging of mature forests and fire suppression on public lands may impact the long-term viability of local populations of this owl (Groves et al. 1997).

Our objective was to utilize recently derived land cover data from Potential Vegetation Type (PVT) model for the Salmon-Challis National Forest (SCNF) for habitat modeling. PVT is a new method for updating actual land cover types using Landsat satellite imagery to possibly improve classification accuracy (Keane et al. 2001). The University of Idaho Remote Sensing Laboratory and SCNF joint research project provided year 2001 cover type (CT) and forest structural stage (SS) data derived using the PVT model. The PVT model used terrain features such as slope, aspect, and elevation to subset Landsat satellite images into potential cover classes before applying more traditional classification methods. Land cover data from both the Idaho Gap program, “Gap based model”, and from the SCNF data, “PVT based model”, were used to construct owl breeding habitat models. Owl breeding habitat parameters included forest cover type, structural stage and elevation range obtained from the literature and the Idaho Conservation Data Center (ICDC 2002).

We hypothesized that PVT based models using CT and SS were comparable to the Gap based model for identifying actual habitat. Coordinates for 11 Flammulated Owl occurrences within a 2900 $km^2$ study area on the SCNF were buffered with 100m, 200m, and 300m concentric circles and assumed to be actual habitat at three different scales. The mean difference between actual and modeled habitat area was compared at each buffer level using a paired t-test. Results of the paired t-test (Table 1) showed no significant difference ($\alpha = .05$) at all three levels between the Gap model and the PVT based model (CT and elevation only). The Gap model estimated that there was more overall habitat in the study area (1072 $km^2$) compared to PVT (1048 $km^2$); the PVT model, however, found 10 to 15 percent more actual habitat at all three buffer levels. The second PVT model included SS (PVT+) and was not significantly different than the Gap model at 100m, but did find significantly less habitat at the 200m and 300m buffer level.

**Table 1**. Results of paired t-tests comparing mean difference between modeled and actual Flammulated Owl breeding habitat.

| Comparison | Buffer | n | df | $x_1$ | $x_2$ | $S^2_{(1)}$ | $S^2_{(2)}$ | t-value | *p* – value |
|---|---|---|---|---|---|---|---|---|---|
| **Gap vs. PVT** | **100** | 11 | 10 | 0.01 | 0.02 | 0.0001 | 0.0001 | -1.23 | 0.123 |
| | **200** | 11 | 10 | 0.06 | 0.07 | 0.0014 | 0.0009 | -1.16 | 0.136 |
| | **300** | 11 | 10 | 0.14 | 0.17 | 0.0057 | 0.0041 | -1.43 | 0.091 |
| **Gap vs. PVT+** | **100** | 11 | 10 | 0.14 | 0.06 | 0.0001 | 0.0001 | 3.57 | 0.079 |
| | **200** | 11 | 10 | 0.06 | 0.03 | 0.0014 | 0.0006 | 2.44 | 0.017***** |
| | **300** | 11 | 10 | 0.01 | 0.01 | 0.0050 | 0.0014 | 1.52 | 0.002***** |

We found that the habitat model utilizing the PVT cover type data provided an alternative to Idaho State Gap land cover data. The PVT+ model that included structural stage found less actual habitat, potentially due to low classification accuracy. In habitats where land cover change occurs frequently due to human or natural disturbances, the PVT classification framework could provide readily updated information for wildlife habitat modeling at the forest planning level. This study provided a useful “proof of concept” exercise for establishing methods to integrate disciplinary aspects of our IGERT research.

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