Remote sensing as a tool for mapping and monitoring habitat: a case study of the St Vincent parrot

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Summary: *Though the indigenous St Vincent parrot (Amazona guildingii) has come back from near extinction, the parrots remain victims of human predation for the pet market and are in danger of habitat loss, habitat fragmentation, and environmental degradation. St Vincent lost 246.5 hectares of forest to agriculture between 1973 and 1983. In the absence of extensive niche and range dynamics research and ultimately an ability to understand sensitivities to habitat loss, remaining habitat should be conserved. Crown Lands provide the bulk of the parrot's habitat and penalties for illegal land use above the 1000 ft contour are not strictly enforced. As many as 41 locations on St Vincent's Crown Lands are falling to subsistence agriculture and logging. This is exacerbated by the inaccessibility of the highland regions and a lack of modern maps. Remote sensing techniques provide an excellent means to map and monitor habitat and aid in land use legislation enforcement. The use of satellite imagery for land use planning and monitoring in the Caribbean should not be dismissed because of cost concerns or classification problems due to extremes in topography.*

Key Words:
LAND USE CHANGE *REMOTE SENSING* *ST VINCENT*

Introduction

Parrots are repeatedly mentioned in history books that speak of adventure in the West Indies. They were given as gifts to arriving explorers, eaten as a source of protein, and often sent to the old world as pets or for plumage. Allen (1961) noted that parrots have been, in turn, admired and mistreated, cherished and destroyed, loved and loathed for centuries. Yet, parrots are experiencing a period of extinction much greater than that of previous centuries and it has been estimated that 100 parrot species are considered 'at risk of extinction' or 'near-threatened' (Beissinger & Snyder, 1992).

All species of the genus *Amazona* reside within Middle and South America. Knobel noted 42 species within the genus in the 1920s (Knobel, 1926) whilst Forshaw (1978) reported 27 species. At present, 15 species are classified as critical, vulnerable, or endangered by the Convention on International Trade in Endangered Species (CITES, 2005) and 20 are listed on the World Conservation Union's *Red List* (IUCN, 2004). Several Amazon parrots have received significant attention, for example, *Amazonia. versicolor,* the indigenous parrot of St Lucia, because of conservation efforts being employed there, and *Amazonia aestiva,* a parrot native to South America, because of its high demand for the pet trade. Sadly, several others have been lost to extinction; two examples are from the Francophone Caribbean islands: *Amazonia violacea* (Guadeloupe) and *Amazonai martinica* (Martinique). Porter (1930), in his *Notes on Rare Parrots of the Genus Amazona,* stated :

> 'One of the saddest things in the life of a keen ornithologist is to see so many wonderful species of birds being exterminated. Creatures whose development and evolution have taken thousands if not millions of years are now by one stroke...swept by the ruthless hand of man into oblivion. They can never be brought back or restored to their place on earth...This especially applies to birds which are confined to small and isolated islands'.

Status of the St Vincent Parrot

The endemic St Vincent Parrot (*Amazonia guildingii*) was named after Reverend Lansdown Guilding, a Fellow of the Linnean Society of London. The species was first recorded and formally named by Vigors in 1836 in the *Proceedings of the Zoological Society.* The parrots mainly reside on the upper east and west slopes of the island's central ridge. The primary habitat is mature forest from c137m-1,000m altitude (Emanoil, 1994). Breeding is restricted to an area between 300m and 700m altitude (Bosche & Wedde, 1984). The St Vincent parrot requires old tree growth for nesting with early successional fruit bearing trees in close proximity. The Vermont Nature Trail (a reserve of 10,870 acres) contains both tree successions; however for additional feeding, the birds travel over a valley to Hermitage (Figure 1). Several trees chosen for cavity nesting also provide food; the Santinay (*Sloanea caribae* and *Sloanea massoni*) and the Gommier (*Dacroydes excelsa*). These trees along with several species of *Ficus* are among the tallest on the island and make up the majority of the rainforest canopy. Diet also includes the fruit of the monkey goblet (*Clusia major*), penny piece (*Pouteria multiflora*), spanish ash (*Inga ingoides*), galba (*Calophyllum calaba*), bullet fruit (*Manikara bidentata*), and occasionally the mango (*Mangifera indica*).

The status of the St Vincent Parrot has been a matter of concern for many years. In the early part of the twentieth century, Knobel (1926) wrote:

> 'Guilding's Parrot...is exceedingly rare, in fact a short time ago it was considered extinct.'

It has been illegal to export these birds without a permit since 1920 and the St Vincent Wildlife Protection Act of 1987 declared hunting and capture illegal. In 1988 the St Vincent government ratified the Convention on International Trade in Endangered Species [CITES] and the bird is listed as 'endangered' in Appendix I, making it illegal to export the parrot or import it into signatory countries. The International Union for the Conserva-

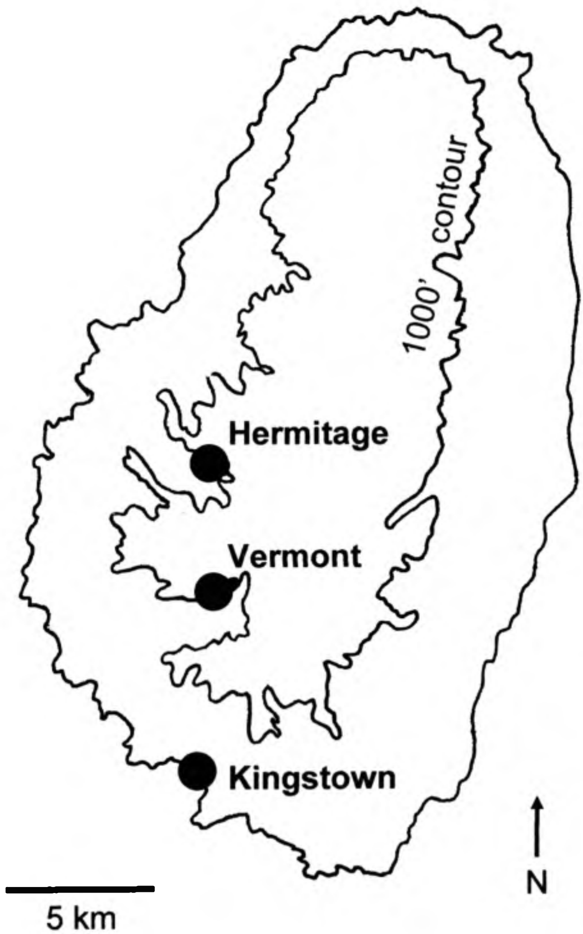

FIGURE 1: St Vincent with 1,000' Crown Land contour

tion of Nature and Natural Resources has the parrot red-listed and categorized as 'vulnerable' in its 2004 assessment (IUCN, 2004).

The illegal export of Caribbean birds goes virtually unnoticed under the façade of the yachting industry and CITES designations have resulted in an increase in the illicit bird trade 'with parrots being most affected' (Forshaw, 1992). For example, a BBC news item in 2000 reported the smuggling of nine endangered parrots into the UK, each worth 50,000 pounds sterling, whilst in Hawaii, Palm Cuckatoos and Hyacinth Macaws are currently fetching US$12,000 and US$9,000 respectively. Six Amazon parrots were recently smuggled into Prague and customs officials estimated the parrots, found in plastic containers, were worth US$3,000-US$4,000 each. *Scientific American* quotes US$10,000 as the going price for a St Vincent Amazon (Graham, 2001). A Fact Sheet produced in 1998 cited an annual capture and sale rate of 10-20 young St Vincent parrots (Bruning, 1998). The latter may be an underestimate of the actual figures because rumours of eggs and hatchlings taken from nests circulate among the Caribbean yachting community as do rumours of survival rates as low as one in 20.

There was a fairly successful attempt during the late 1980s to educate Vincentian youth and to increase the general awareness of the situation. The RARE Center for Tropical Bird Conservation of Arlington, Virginia, donated time and money to an education programme that reached 18,000 children (Wille, 1991). Evidence of the programme remains on the landscape; murals in town depict the parrot along with a conservation message, and a World Wildlife Fund sponsored Division of Forestry poster reads 'Symbolic of our uniqueness, beauty, freedom and independence, the St Vincent Parrot is the proud national bird of St Vincent and the Grenadines'.

The most recent official population statistic is of 800 individuals (IUCN, 2004). This is quite an increase from the 450 individuals recorded in a 1973 report by Tom Nichols of Houston Zoo. However, it is important to note that birds endemic to single islands tend to have less genetic diversity than those with a broad range, and are thus more susceptible to extinction. The IUCN's *Red List* states that the bird remains 'capable of becoming Critically Endangered or even Extinct in a very short time period' (IUCN, 2004). Further, the Wildlife Conservation Society of New York has funded genetic analysis of captive St Vincent parrots in the region and this information can be used to 'implement management strategies to ensure a genetically diverse population that is better able to withstand threats to its survival' (Graham, 2001). The Rare Species Conservatory Foundation is also working to improve the population by integrating data from GPS into a nest monitoring programme.

The demands of the pet trade have undoubtedly contributed to the parrot's struggle for survival, and of course, a steady rise in human population is another contributing proximate factor. The island's human population increased from 44,500 in 1921 to 110,000 in 1985. In 1982 it was estimated that 74 percent of the population lived in the countryside (Meditz & Hanratty, 1987). The national population actually decreased by 1991 to less than 99,000, but has since increased to 102,848 (Brinkhoff, 2003).

Habitat Loss

A primary concern for Amazon parrots is that of habitat loss, environmental degradation, and habitat fragmentation; Latin America and the Caribbean lost 5.3 million hectares of forest between 1980 and 1995 (Salim & Ullsten, 1999). The Caribbean islands are a biodiversity hotspot and Conservation International cites habitat loss as a leading concern for all threatened taxonomic groups in the region (Conservationa International, 2005). The IUCN (2004) and the Audubon Society (2000), among many other conservation groups, refer to parrot habitat loss as a significant concern.

Land-use regulation has been virtually unchecked throughout the island's history and vast tracks of land are still being converted to agriculture. Though most Crown Lands (land higher than 1000ft) are designated Forest Reserves, rural squatting goes practically unabated. The break up of estates into smaller subsistence tracts is also a concern. Zoning laws were introduced in 1996, but land use enforcement remains a problem. Another habitat concern is the plan for the St Vincent Cross Country Road which could significantly impact the parrot habitat.

The Forestry Division works closely with the St Vincent Parrot Research Team. However, according to Christian (1993) conservation is low on the national priority list, and as a result very limited national resources have been put at the disposal of the division. The government of St Vincent is aware of habitat loss and the overall attitude seems positive toward dealing with the ongoing problem of deforestation. However, there are simply not enough resources to monitor agricultural encroachment into Crown Lands as road infrastructure in the interior is at present virtually non-existent (which is, obviously, good for the parrots).

In this paper, the historical loss of habitat on mainland St Vincent was verified by digital quantification of land cover change. Advancement of cultivation into the island's interior was quantified via ESRI *Arcview* software by digitizing two sets of the UK Directorate of Overseas Survey's topographic maps dated 1973and 1983. According to the maps, the total land area of St. Vincent was calculated to be 338,504,458 m^2. In 1973, just over 38 percent of the total land area was classified as agricultural land (129,941,565 m^2). By 1983 the amount of agricultural land had increased to over 39 percent (132,406,159 m^2). Thus the amount of land converted to agriculture between 1973 and 1983 was 2,464,594 m^2. The biggest concern was that analysis of the the data revealed 19 areas where agriculture is encroaching on the 1,000 ft Crown Land contour and 41 areas where farming has encroached past the contour. A 1993 topographic map is presently available and the analysis will be repeated for this date in the coming months.

Remote Sensing as Appropriate Technology

The government division responsible for parrot conservation is poorly endowed with resources, but quantitative habitat mapping, habitat monitoring, and enforced habitat protection legislation are essential to conservation efforts. The local Ministry of Finance and Planning has a GIS capabiltiy, but their staff and budget are limited and a database of forest cover is not planned in the foreseeable future. The principal tool for this endeavour is applied remote sensing. However, there are perceived obstacles (costs of data, software, and training) and real obstacles (image classification problems due to cloud cover and orographic shadow) in the region. However, the author suggests the following applied mapping and monitoring techniques to help negotiate many of these obstacles.

Imagery and Software

One Landsat Multispectral Scanner (MSS) satellite image, recorded on March 24th, 1986, was used in the research. This 80m resolution image is downloadable free of cost at the University of Maryland's Global Land Cover Facility (GLCF) website. Free imagery is also available for Antigua, Guadeloupe, and Barbados. Clark Labs' IDRISI software was used for image processing. A government license for IDRISI is available for $1000, but the institution recognizes the need to donate its software to organizations that are poor in financial resources. Non-profit agencies can purchase software with more powerful capabilities from Leica Geosystems at significantly discounted prices. Purdue Research Foundation's MultiSpec software package is available for free and is particularly user friendly (http://dynamo.ecn.purdue.edu/~biehl/MultiSpec).

Image classification

Image processing in the region has two obstacles, cloud cover and cloud shadow. Because of the orographic effect, it is virtually impossible to obtain a cloud free image. There are methods of masking out these areas and one simply has to accept the reality that part of the island will not be classified. The other regional issue is insolation shadow. When looking at the MSS image at hand, the west side of the island is in shadow, the east is in direct sunlight. The shadowed western slopes have lower reflectance values and the sunlit eastern slopes have exaggerated reflectance values. This topographic influence results in the same type of vegetation being classified differently on either side of the island.

Though reflectance values are different for the same type of vegetation on either side of the main ridge; the ratio between the values from wavelength band to wavelength band remain the same. If we imagine two pixels of the same vegetation, one in shadow and one in direct sunlight, the spectral signatures are similar, it is the brightness levels that are different. Image ratioing is a technique that utilizes spectral information, but displays the information as ratio data. A ratioed image equalizes the brightness information but retains spectral information. The red/IR ratio is suitable for vegetation mapping, and when performed, topographic effects on the imagery disappear and familiar vegetation patterns emerge.

Using a combination of aerial photographs, photographs taken and catalogued during field visits, and consultations with a local Vincentian, the red/IR ratio image was classified into four vegetation density classes and one cloud/cloud shadow class. Since the St Vincent Parrot is a canopy dweller that eats, breeds, and roosts only in an environment where the vegetation is dense, it can be argued that vegetation density determines the limits of the normal parrot range. Thus the concept of density was used for land cover types. The area of each vegetation density class was calculated.

Results and accuracy assessment

For the purpose of the parrot habitat map (Figure 2), the three lower vegetation density classes were combined (for a thorough analysis of each of the original vegetation classes see Delahunty, 1997). The high density vegetation class – parrot habitat – includes the coconut/banana complex, palm break, rainforest, and secondary rainforest. This vegetation class was represented on 177,219,954 m^2 of the island. Aerial photographs of the same time period were used to assess the accuracy of the classification. The accuracy assessment resulted in 82 percent of the pixels being classified correctly (Kappa Index 76 percent). Essentially, the errors related to vegetation transition zones.

Discussion

This project resulted in a digital map of parrot habitat/high density vegetation cover. The digital map quantifies habitat at the time the image was recorded. In the future it can be

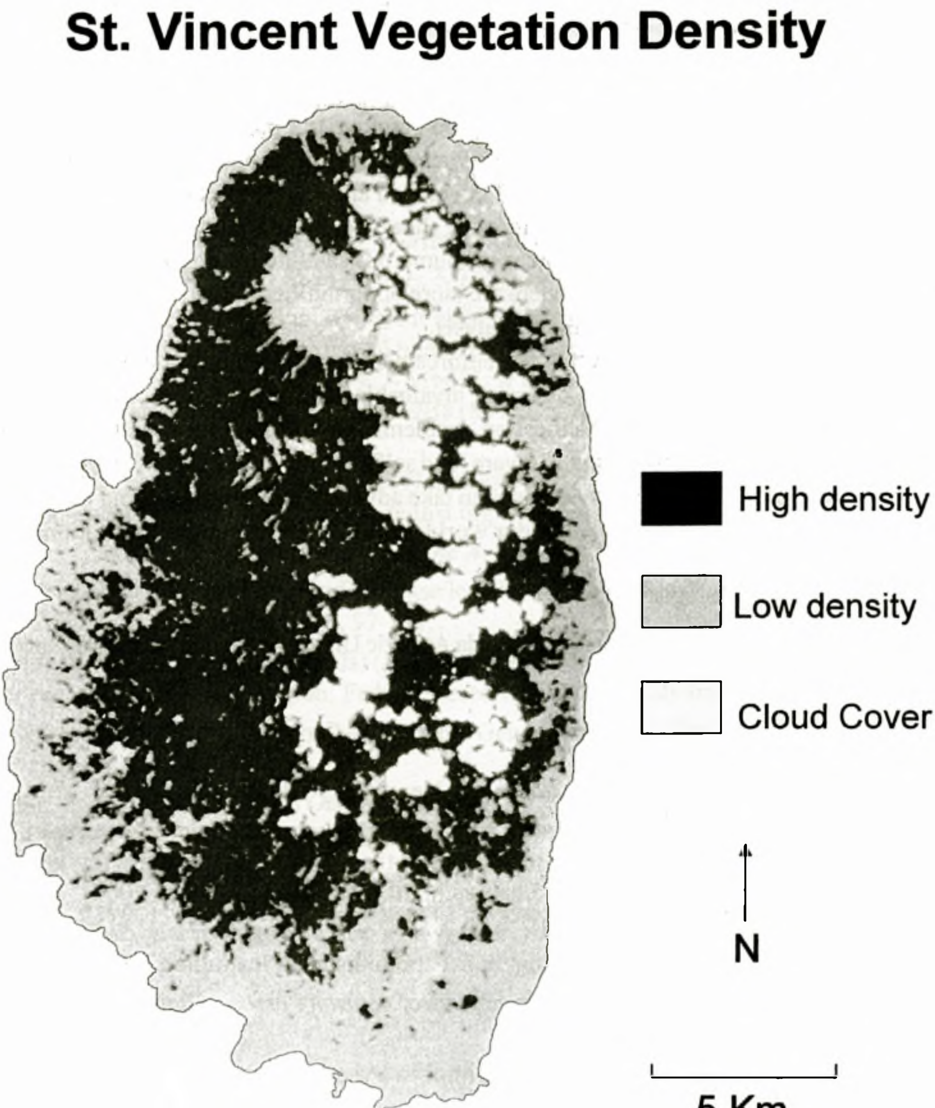

FIGURE 2: St Vincent vegetation density map
NOTE: High density vegetation (A. guildinglii habitat) includes the coconut/banana palm break, rainforest and secondary rainforest

coupled with another classified image (when the next relatively cloud free image becomes available) to detect and quantify changes in habitat extent and fragmentation. The modern image could then be reclassified to exclude the coconut/banana complex and the 1,000ft contour and a roads coverage could be added. This would facilitate tremendously the identification and location of illegal habitat encroachment and would enable the Forestry Division to more effectively use time in the field.

Monitoring encroachment on Crown Lands is an important issue in the region (Limbird, 1995). The above process can be employed to map, quantify, and compare numerous types of land cover and help address various planning issues. Additional uses include quantification and mapping of developed areas, quantification and mapping of areas dedicated to certain crops, performing shoreline analysis, and it could perhaps help to promote alternative tourism. There are numerous satellite images available that have cloud free lower elevations thus there are more opportunities in terms of data for coastal mapping and associated time series analysis.

Land use/habitat monitoring and enforcement benefits not only the species at hand, but provides a safeguard for biodiversity, invaluable watersheds, and ecotourism. There are techniques to remedy classification problems due to topography and there is free satellite imagery and processing software (and self training with online help is plausible). Caribbean governments are encouraged to take advantage of remote sensing technology to facilitate their attempts to better our world through planning and conservation.

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References

Allen, R.P. (1961) *Birds of the Caribbean*, New York: Viking Press.

Audubon Society (2000) *Action plan aims to save the world's threatened parrots*, Audubon Latin America Bulletin No. 6. <http://www.audubon.org/local/latin/bulletin6/habitat.html> [Accessed 17 March 2005].

Beissinger, S.R. & N.F.R. Snyder (1992) *New world parrots in crisis: Solutions from conservation biology,* Washington D.C.: Smithsonian Institution Press.

Bosche, K. & U. Wedde (1984) *Encyclopedia of Amazon Parrots,* Germany: THF Publications.

Brinkhoff, T (2003) *City population* <http://www.citypopulation.de/StVincent.html> [Accessed 17 March 2005].

Bruning, D (1998) *St. Vincent parrot 98 fact sheet,* Maryland: American Zoo and Acquarium Association.

Christian, C.S. (1993) 'The challenge of parrot conservation in St. Vincent and the Grenadines', *Journal of Biogeography*, 20(5), 463-469.

Conservation International (2005) *Biodiversity hotspots: Caribbean islands* http://www.biodiversityhotspots.org/xp/Hotspots/caribbean/biodiversity.xml> [Accessed 17 March 2005].

Convention on International Trade in Endangered Species of Wild Flora and Fauna (2005) *Appendices I, II and III* <http://www.cites.org/eng/app/appendices.shtml> [Accessed 17 March 2005].

Delahunty, J. (1997) *Image ratioing as appropriate technology for monitoring vegetation cover in the Caribbean.* MA Thesis. Florida Atlantic University.

Emanoil, M. (ed.) (1994) *Encyclopedia of Endangered Species,* London: Gale Research Inc.

Forshaw, J.M. (1978) *Parrots of the World.* 2nd ed, Devon: David and Charles.

Forshaw, J.M. (1992) *Australian Parrots,* Melbourne: Lansdowne Press.

Graham, S. (2001) 'Protecting StVincent amazon parrots: DNA 'featherprinting' may help scientists to thwart the illegal trade of a threatened species of parrot', *Scientific American, InFocus, Sep4.* <http://www.sciam.com/article.cfm?articleID=0006DF41-A667-1C75-9B81809EC588EF21> [Accessed 17 March 2005].

International Union for Conservation of Nature and Natural Resources (2004) *Red List of threatened species* <http://www.redlist.org> [Accessed 17 March 2005].

Knobel, E.M. (1926) 'Amazon Parrots', *The Avicultural Magazine*, 4 (Sep), 229-234.

Limbird, A. (1995) 'Land use and land use legislation for Crown Lands in St Vincent', *Caribbean Geography*, 6 (2), 97-111.

Meditz, S.W. & D.M. Hanratty (eds) (1987) *Islands of the Commonwealth Caribbean: A regional study,* Washington: Federal Research Division, Library of Congress.

Porter, S. (1930) Notes on Rare Parrots of the Genus Amazona, *The Avicultural Magazine, 8 (Jan), 2.*

Sallim, E. & O. Ullsten (1999) *Our forests our future,* Cambridge: Cambridge University Press.

Vigors (1836) 'St Vincent', *Proceedings of the Zoological Society,* London, p.80.

Wille, C. (1991) 'Paul Butler: Parrot man of the Caribbean', *American Birds,* Spring.

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