Shorebird Habitat Availability Assessment of Agricultural Fields Using a Digital Aerial Video System[1]

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Abstract

Field and wetland conditions in the rice prairies of Louisiana and Texas are highly dynamic habitats. Rice prairies are important habitat for many species of migratory birds, including shorebirds, wading birds, and waterfowl. Ground sampling a variety of fields to assess habitat availability is very labor intensive, and accessibility to private lands makes statistical habitat sampling almost impossible. Aerial video is a tool we can use for assessing availability of these highly ephemeral habitats because of the short-duration repeatability of the surveys. The strong statistical basis of line transect theory allows quantitative estimation of habitat availability. We used ground surveys of field conditions and shorebird ground counts to correlate spectral signatures with shorebird habitat availability. This video system can also be used to identify and map distribution of invasive plant species known to affect suitability of stopover habitat for shorebirds and landbirds.

Key words: aerial videography, agricultural fields, habitat assessment, Louisiana, remote sensing, shorebirds.

Introduction

Field and wetland conditions in the rice prairies of Louisiana and Texas are highly dynamic habitats. Rice prairies are important habitat for many species of migratory birds, including shorebirds, wading birds, and waterfowl. For example, Wood Storks (*Mycteria americana*) arrive in the rice prairies during post-nesting dispersal in July. Being a tactile feeder, they are dependent on wetlands, especially ephemeral wetlands that are drying up which concentrates their prey. Permanent crawfish ponds are usually drained during the summer months, providing ideal habitat for Wood Storks. Because draining crawfish ponds only provide stork habitat for a few days, the birds are continuously sampling the landscape. Currently, there are no generally accepted methods of sampling these habitats. Accessibility to private lands makes statistical habitat sampling difficult, at best.

Several studies have used Landsat Thematic Mapper (TM) imagery to identify shorebird nesting habitats in the arctic (Gratto-Trevor 1996, Morrison 1997). These studies have classified habitats, determined breeding species composition and densities for identified habitats, and extrapolated breeding populations for relatively large habitat areas in the arctic. Yates and Goss-Custard (1997) used Landsat TM imagery to determine intertidal sediment distribution and developed models to predict abundance of shorebird species. Spell et al. (1995) used Landsat TM imagery to determine acreage of winter-flooded rice available to wintering birds. They used summer imagery to determine acreage of rice in production, and winter images to measure extent of flooding. Due to few cloud-free-days, the authors experienced problems obtaining winter images.

Aerial video would provide methodology for assessing availability of these highly ephemeral habitats because of the short-duration repeatability of the surveys. The strong statistical basis of line transect theory would provide the methodology for providing quantitative estimation of availability (Buckland et al. 2001). Additionally, for species such as Wood Storks, differential use of wetland classes could be determined, providing habitat use information as well. For habitats, which are more stable than agricultural wetlands, aerial videography would provide a method of obtaining statistically valid samples, which could be applied to questions of spatial distribution of different habitat categories.

The proliferation of low cost multi-spectral CCD video technology in combination with the Global Positioning System (GPS) has progressed to the point where quantifiable and meaningful results can be derived from low altitude aerial digital video systems. This low cost technology will provide meaningful and sometimes critical data that will be required for regional and site-specific land management. Historically, video has not had the resolution to be used for spatial processing, but newer digital systems have expanded the capabilities. Linking with GPS systems allows repeatability of sampling that was unavailable in the past. When

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Table 1– *Comparison of sensor characteristics and costs of commonly used images in remote sensing.*

Sensor platform	Num. of bands	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)	Approx. cost[1] per scene ($)
CIR Photo[2]	3	2.4	6.6	Varies	60
Landsat	7	30	185	16	1,000
Spot 4	4	20	60	3	2,500[3]
Ikonos	4	4	11	11	5,000[4]

[1] Image acquisition only, no special processing.
[2] Acquired at 1:24,000 scale and scanned at 300 dpi.
[3] Custom acquisition (customer controlled new image acquisition).
[4] CARTERRA Precision $66/sq. km to $99/sq. km depending upon level of preprocessing required. Partial scene purchase available. $5,000 minimum purchase.

compared to satellite acquisition systems, such as Landsat TM imagery, airborne video systems have the additional capability of varying the temporal and spatial resolution to fit the needs of individual projects. In addition, these systems have the potential for extremely fast post-processing and at a low cost (*table 1*).

The objective of this study was to develop a process of image acquisition, image processing, and incorporation of field characteristics and shorebird abundance to evaluate aerial videography for predicting shorebird use of agricultural fields.

Methods

Our study focused on agricultural fields within the Mermentau River Basin in southwestern Louisiana (*fig. 1*). Roadside transects sampling from 10-16 fields were established in 1996-97 and have been monitored periodically for avian use since. A stratified random sample of fields was established. The number of transects per Parish was weighted for rice production. Random coordinates within the Parish were used to establish a starting point. Fields actively being farmed for rice were selected for transects in 1996-97. We have maintained these fields in the study even if they have been removed from rice production, or are used for alternative crops (i.e., soybeans). Each transect averages approximately 6.5 km in length.

We used aerial videography to assess habitat conditions on 7 transects containing 83 identified fields from the earlier study (W. Norling, National Wetlands Research Center, unpubl. data). Within a rice field, contour levees exist to allow control of water levels. Because each section of a field within a contour levee may provide different habitat conditions (i.e., when a field is being flooded, some sections may be flooded while others are dry), we treated each section within contour levees as separate units. Consequently, the 83 fields consisted of over 300 units that were sampled with both ground-truthing and counts of shorebirds using the units.

For each flight, the image acquisition phase consists of the actual flight, acquiring the images and raw data, and then the post processing to geo-rectified images. This involved an airplane equipped with a GPS unit linked to a natural color video camera and a color infrared camera (*fig. 2*). GPS coordinates were recorded in the audio tracks of both video cameras and were later extracted in order to match the video frames with their exact positions. These video frames along with their GPS coordinates were then used to make geographically correct mosaics.

The processing phase consists of spatial processing. This involved a manual interpretation of field conditions using pre-existing methodologies used by previous National Wetlands Research Center rice field studies (W. Norling, NWRC, unpubl. data). Index conditions were entered into the existing GIS rice field database along with the ground-truth field collected data for accuracy comparisons. Individual frames from the video have been extracted to develop a mosaic image of each transect and imported into Arcview for analysis (*fig. 3*).

The final phase consisted of using the processed data to determine meaningful biological results. Concurrent with the aerial data acquisition, transects were surveyed from the ground. Field conditions were recorded and numbers and species of waterbirds using the fields recorded. Field conditions from aerial video were determined by an observer without prior knowledge of the field conditions reported by the ground observer. Fields were classified as to amount of flooding and green vegetation using both the color infrared and natural color video. Classification levels were 0, 1-24, 25-49, 50-74, 75-99, and 100 percent coverage. Results from the video observer were compared with the ground observations to determine error rates of classification. Classification error was determined by comparing the video classification with the ground observation for each unit. Because there were 6 possible classifications, 0 coverage was given a 1 and 100 percent coverage a 6, we compared classification by subtracting ground

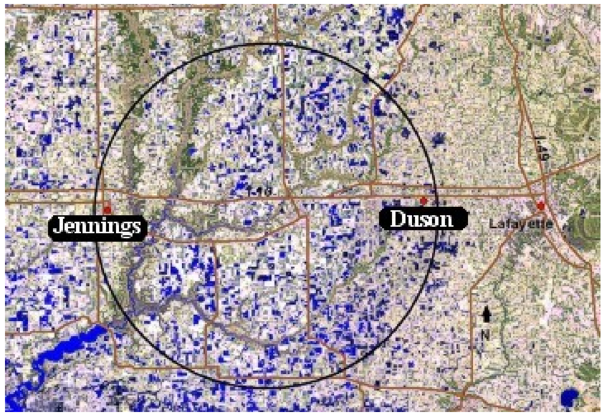

Figure 1— Study area in southwest Louisiana. The Mermentau Drainage has extensive agricultural areas between riparian zones. Most agricultural lands are farmed for rice, with fallow or soybean rotations. Notice the extensive flooding of agricultural fields in this Thematic Mapper image.

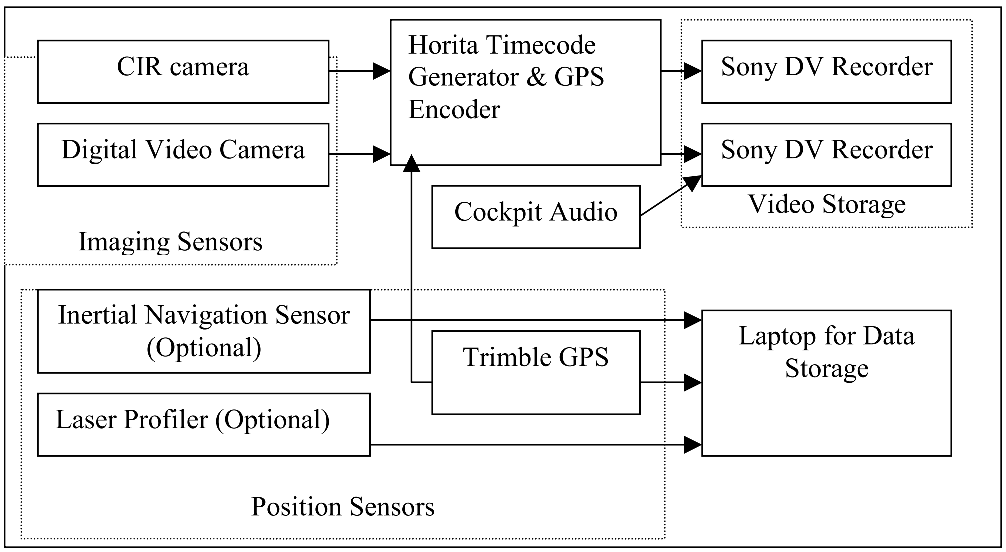

Figure 2— Links of video sensors with the GPS unit to allow exact locations of video frames to be determined.

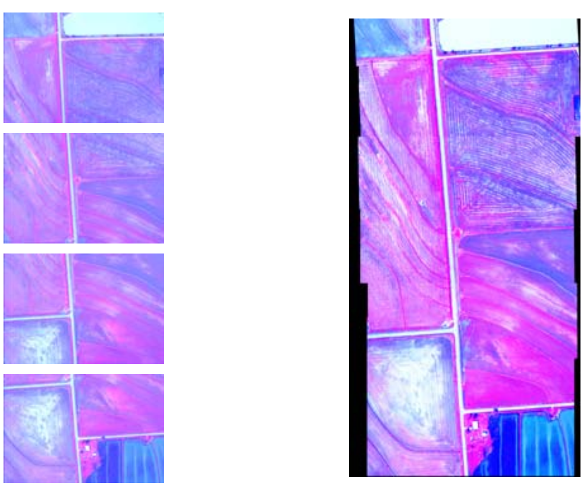

Figure 3— Individual frames from the video are captured to develop a mosaic of the surveyed area.

observation from the video classification. A comparison value of 0 corresponds with complete agreement in classification, while a ±5 is a complete disagreement in classification. For example, if a dry field was classified as 100 percent flooded, classification agreement would be calculated as 1-6, or –5, complete disagreement.

Amount of flooding and amount of green vegetation were chosen because they can be determined from the aerial video, such conditions are also known to influence relative abundance and species richness of shorebirds (W. Norling, NWRC, unpubl. data).

Results

Four concurrent flight-ground counts were completed for this study. Over 750 field units were available for comparison between photointerpretation and ground observations. Misclassification rates were higher for determination of flooding than for estimates of green vegetation for both Color Infrared Video (CIVR) and Natural Color Video (NCV; *tables 2, 3, 4, and 5*). In several instances interpretation of the aerial images were misclassified when newly worked soil was classified as shallow, turbid flooding. Turbid water in CIRV has an indistinct spectral signature compared with clear that has a distinct spectral signature.

If value levels of 0 or ±1 are accepted as reasonable agreement between classifications over all flights, CIRV was most accurate for determination of flooding with 62.4 percent of the classifications in agreement. Classification agreement for NCV was 55.9 percent. Classification agreement was less for green vegetation for both formats, with CIRV being 46.6 percent, and NCV being 46.6 percent. Values suggesting misclassification, ±4 or 5, were similar for both formats for both vegetation and flooding, ranging from 28.5 percent for NCV for vegetation to 38.3 percent NCV for flooding.

Discussion

Aerial videography provides researchers the ability to rapidly assess habitat availability with a high degree of repeatability. Shorebird habitats in the rice prairies of Louisiana and Texas are highly dynamic habitats. Fields may be plowed in fall or spring, then flooded in the spring, leveled while flooded, and then seeded. In Louisiana, aerial seeding of rice is common, with fields flooded for approximately two weeks before being drained to allow the rice to sprout. During draw down, fields are heavily used by shorebirds. Fields are re-flooded after the rice has sprouted and the fields again receive substantial shorebird use. Because these habitats are so dynamic (Lawler 2001), aerial videography allows sampling of habitat to be repeated over short time intervals, allowing managers to monitor habitat availability throughout the period. During peak shorebird migration along the Gulf Coast, cloud cover often limits the availability of scenes for satellite based collection systems. Spell et al. (1995) identified the difficulty of obtaining Landsat images during the winter in the Central Valley of California.

Many remote-sensing platforms are either cost prohibitive, are too coarse of a scale to identify specific habitat characteristics, or timing of imagery is inappropriate for measurement of availability of the habitats of interest. Aerial videography is an efficient method of collecting habitat data that is less expensive, repeatable over short time duration, and able to collect fine-scale spatial data. Initial costs for equipping the fixed-wing aircraft with the aerial videography components was a one-time cost of approximately $20,000. After equipping the aircraft, costs are limited to those incurred by flight time, and personnel to extract individual frames from the video to be used to develop a mosaic of the study area (*fig. 3*). Once geo-referenced, the data can be used as data layers in a GIS analysis of habitat availability and change.

Table 2— *Comparison of percent of a field flooded from Color Infrared Video when compared with ground observations. Fields were classified as being 0, 1-24, 25-49, 50-74, 75-99, and 100 percent flooded. Value of 0 corresponds to agreement between observers, while a value of ±5 corresponds to complete classification difference.*

Survey number	Fields surveyed	Value = 0	Value = ±1	Value = ±2	Value = ±3	Value = ±4	Value = ±5
1	162	43	13	6	2	29	69
2	162	128	9	15	5	15	24
3	205	113	26	2	9	15	40
4	203	127	19	5	3	15	34
Totals	766	411	67	28	19	74	167

Table 3— *Comparison of percent with green vegetation from Color Infrared Video when compared with ground observations. Fields were classified as 0, 1-24, 25-49, 50-74, 75-99, and 100 percent vegetated. Value of 0 corresponds to agreement between observers, while a value of ±5 corresponds to complete classification difference.*

Survey number	Fields surveyed	Value = 0	Value = ±1	Value = ±2	Value = ±3	Value = ±4	Value = ±5
1	162	73	22	18	11	24	14
2	185	49	24	26	7	58	21
3	205	52	17	29	39	53	15
4	203	86	34	18	25	31	9
Totals	766	260	97	91	82	166	59

Table 4— *Comparison of percent of a field flooded from Natural Color Video when compared with ground observations. Fields were classified 0, 1-24, 25-49, 50-74, 75-99, and 100 percent flooded. Value of 0 corresponds to agreement between observers, while a value of ±5 corresponds to complete classification difference.*

Survey number	Fields surveyed	Value = 0	Value = ±1	Value = ±2	Value = ±3	Value = ±4	Value = ±5
1	187	61	14	4	2	22	84
2	197	86	11	7	5	34	54
3	207	122	12	8	9	18	38
4	203	127	11	3	9	9	45
Totals	794	396	48	22	25	83	221

Table 5— *Comparison of percent of a field with green vegetation from Natural Color Video when compared with ground observations. Fields were classified 0, 1-24, 25-49, 50-74, 75-99, and 100 percent vegetated. Value of 0 corresponds to agreement between observers, while a value of ±5 corresponds to complete classification difference.*

Survey number	Fields surveyed	Value = 0	Value = ±1	Value = ±2	Value = ±3	Value = ±4	Value = ±5
1	187	87	21	15	16	17	31
2	196	54	25	23	24	35	35
3	207	51	14	46	34	42	20
4	202	69	43	20	24	38	8
Totals	792	261	103	104	98	132	94

Several factors may influence interpretation of the video when compared with ground observations. Vegetative cover was probably overestimated from ground observations. Oblique observation angles suggested more dense vegetative coverage than the overhead angle revealed, affecting correspondence with the video classification. Consequently, best agreement would be among fields with no vegetation or extremely dense vegetation and less agreement with intermediate vegetation densities asking whether a field was 30 percent vegetated or 75 percent covered with green vegetation. Similarly, an oblique angle tends to reduce the apparent size of the field, resulting in an inflated estimate of percent flooded for ground observations.

Sun angle influenced the ability of the video observer to distinguish field characteristics. Flooding was most easily detected by reflectance off the water surface. Light cloud cover made detection of flooding more difficult. Optimal flight conditions were during midday with minimal cloud cover. Because of reflectance, flight paths in an east-west direction made detection of flooding easier than north-south orientations.

Training of the video interpreter improved correspondence between observations. In our study, initial classification was done with no training of the video interpreter. When we compared misclassifications, it became apparent that recently disked fields were classified as shallow flooding by the video interpreter because of the similarity with shallow, turbid water. After comparing several shallow, flooded fields with recently disked fields, subtle differences in the spectral signatures could be detected, resulting in improved classification of other fields. Combining both CIRV and NCV improved classification compared to using only one format. Training in all aspects of the data collection is important for accuracy and consistency of interpretation of video data.

We recommend that individuals using aerial videography standardize data collection with regard to time of day of flights, flight altitude, cloud cover, and orientation to the sun to optimize the video quality. Additionally, ground-truthing observations are necessary for quality control of data, and to use in training interpreters of the video. Linking wildlife use with habitat characteristics with easily identified spectral characteristics simplifies the data analyses. We originally had too many habitat categories and it affected interpretation.

Optimization of data collection to address specific needs can be controlled by determining optimal scale of data collected through flight altitude (*fig. 4*) and timing. Researchers in remote locations can use this system to collect and acquire meaningful data in a relatively short time period. Airborne video systems also have the capability to provide information for efficient rapid response during emergency situations, such as hurricanes. We envision applications of videography for other applications where land managers require quick response, such as oil spill clean up, fires, monitoring exotic species, and storm or pest damage.

Acknowledgments

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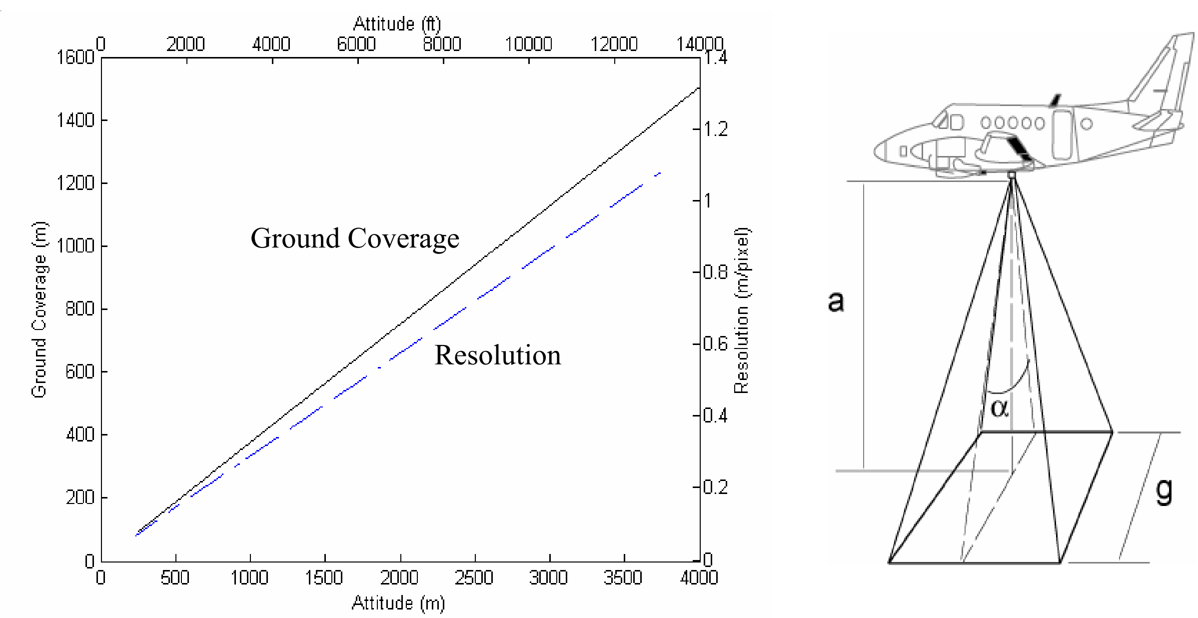

Figure 4— Relation between ground coverage and resolution for mission planning.