Creating A Cost-Effective Aerial Surveillance System

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ABSTRACT

OFFICIAL ABSTRACT and CERTIFICATION

Creating A Cost-Effective Aerial Surveillance System

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There are over 1.5 million incidences of property damage caused by wild animals in civilized areas annually. Damage resulting from animals traveling in groups often is of the most severe and costly in nature. By monitoring the activities of animal group migrations (particularly those of javelinas), predictions can be made as to where damage by wild animal groups is likely to occur and can be prevented. After identifying likely areas of damage, preventative measures can be developed to discourage wild animals from entering civilized areas and causing damage. This study investigated the creation of a low cost aerial surveillance system which could record time lapse images of a given area to monitor wild animal pack movements.

Originally, we planned to utilize an infrared camera to allow for easier night-time tracking, however, infrared technology is extremely expensive. Instead, we opted for a much cheaper time lapse camera specifically designed for hunters to monitor wild animals. Having the new camera in hand, we found after a few preliminary tests that weather balloons were not well suited for our project. The weather balloon was replaced with a specially engineered balloon designed for durability and sustained flight. With these alterations, our surveillance system became both cheaper to construct, and more practical in terms of sustainability and re-usability.

Category
Pick one only—mark an "X" in box at right

- ☐ Animal Sciences
- ☐ Behavioral and Social Science
- ☐ Biochemistry
- ☐ Cellular & Molecular Biology
- ☐ Chemistry
- ☐ Computer Science
- ☐ Earth Science
- ☑ Eng: Electrical & Mechanical
- ☐ Eng: Materials & Bioengineering
- ☐ Energy & Transportation
- ☐ Environmental Management
- ☐ Environmental Sciences
- ☐ Mathematical Sciences
- ☐ Medicine and Health
- ☐ Microbiology
- ☐ Plant Sciences
- ☐ Physics and Astronomy

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check ALL that apply):

   ☐ human subjects ☐ potentially hazardous biological agents
   ☐ vertebrate animals ☐ microorganisms ☐ rDNA ☐ tissue

2. This abstract describes only procedures performed by me/us, reflects my/our own independent research, and represents one year's work only ☑ Yes ☐ No

3. I/we worked or used equipment in a regulated research institution or industrial setting: ☐ Yes ☑ No

4. This project is a continuation of previous research. ☐ Yes ☑ No

5. My display board includes non-published photographs/visual depictions of humans (other than myself): ☑ Yes ☐ No

6. I/we hereby certify that the abstract and responses to the above statements are correct and properly reflect my/our own work. ☑ Yes ☐ No

This stamp or embossed seal attests that this project is in compliance with all federal and state laws and regulations and that all appropriate reviews and approvals have been obtained including the final clearance by the Scientific Review Committee.

RESEARCH PLAN

Initial Question

Hypothesis

Procedure

Problems/Solutions

Bibliography

Initial Question

Is it possible to create a cheap surveillance system to monitor the movement of wild animal herds?

Hypothesis

Property damage due to wild animals is due to destruction of their natural habitat from construction. The animals are being forced out of their old habitat and into more populated sections of land. By monitoring wild animal movement it would be possible to redirect their search for a new habitat, and creating an aerial surveillance system to monitor their movement can be done on the cheap.

Procedure

1. Research
   - Referenced online journals written by people who had run past experiments with weather balloons
   - Calculated necessary balloon diameter to achieve 'x' amount of lift force
   - Investigate Federal Aviation Administration regulations
2. Outline initial schematics.
   - Compiled the best designs found online along with initial ideas of our own to create a prototype
   - Made a list of all necessary parts
3. Research equipment
   - Searched online for all necessary equipment
   - Narrowed list to include only the cheapest and best rated equipment
4. Obtain equipment
   - Bought equipment from various sources as funding permitted
   - Rented helium tank
5. Assembly
   - Constructed enclosure for time lapse camera
   - Attached streamers to tether every 50ft
   - Anchor ends of tether to two separate rooftops
   - fill weather balloon with helium
6. Testing
   - Launched balloon and photographed from various different heights to collect data relating how a javelina-sized object appears in photos taken from varying heights

Problems/Solutions

1. Expensive Infrared cameras

Solution - Use a hunter's time lapse camera instead.

2. FAA regulations (500ft height limit and warning/lighting system)

Solution - Test only at heights ranging from 400 - 450ft, attach aviation orange streamers to tether at 50ft increments, and attach solar powered LEDs to the surveillance system

3. Tangling fishing wire

Solution - Immediately wind fishing wire around spools to prevent it from tangling with itself whenever not in use

4. Balloon popping

Solution - Launch far from trees or any sharp surfaces and do not use weather balloons (latex is too weak)

5. Not enough lift

Solution - The balloon must be filled to a diameter over 6ft, because although a 6ft diameter should supply enough lift for our system, it does not account for atmospheric conditions such as wind

6. High leak rates in weather balloons

Solution - Use a specially engineered type of balloon which is refillable and which has a comparatively small leak rate to weather balloons

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RESEARCH REPORT

Initial Problems/Questions

Solutions

Hypothesis

Equipment

Cost of Equipment

Tests

Data

Conclusions

Applications

Initial Problems/Questions

1. Problem
    a. There have been many recent complaints of wild animal damage to property in Fountain Hills, Arizona.
2. Initial Questions
    a. Is there a way we could monitor wild animal movements to discover trends and figure out methods of damage reduction?
    b. Is there a way we could accomplish this in a cost-effective manner?
    c. What materials should be used?

Solutions

1. Is there a way we could monitor wild animal movements to discover trends and figure out methods of damage reduction?
    a. Using a time-lapse camera, we could take pictures of wild animals and monitor their behaviors.
    b. Elevating this camera hundreds of feet above the ground would allow us to greatly increase our field of vision.
        i. This would help us to monitor animal movement over greater distances, allowing us to better analyze broad trends in movement and activity.
2. Is there a way we could accomplish this in a cost-effective manner? What materials should be used?
    a. By attaching an inexpensive time-lapse camera to a weather balloon, we could elevate the camera and increase our field of vision.
        i. By insulating the camera in cheap foam board, we could minimize any damage to the camera.
        ii. By covering the balloon with a tarp, we could protect it from the elements.
        iii. We could tether the balloon to the ground using fishing wire, and hold it down using cinder blocks.
        iv. To hold it all together, we could use simple caribiners, pulleys, and duct tape.

Hypothesis

Property damage due to wild animals is due to destruction of their natural habitat from construction. The animals are being forced out of their old habitat and into more populated sections of land. By monitoring wild animal movement it would be possible to redirect their search for a new habitat, and creating an aerial surveillance system to monitor their movement can be done on the cheap.

Equipment

We purchased one time-lapse camera, and surrounded it in a foam board box.

Using 5 caribiners, 4 pulleys, and 100 lb rated fishing line, we attached the foam board box to an 8' diameter latex weather balloon covered by a 12' x 20' tarp.

We tethered the system to the ground using more fishing line, and anchored it down using two cinder blocks.

Due to Federal Aviation Administration regulations regarding systems like the one described above, we also attached orange flags every 50' along the tethers. In addition, we attached high visibility LED's to the foam board box.

Cost of Equipment Used in Tests 1-4

Cinder blocks:	2 at $2.50
Nylon string:	400' at $1.00
Fishing line:	2 rolls at $10.00
Foam board:	$3.00
Camera:	$100.00
Carabiners:	5 at $10.00
Latex weather balloon:	2 at $20.00
Tarp:	2 at $30.00
Pulleys:	4 at $4.00
Flashing LED's:	2 at $10.00
Orange flags:	3 at $4.00
Duct tape:	2 rolls at $5.00
Total:	$337.00

Test 1

The length of the tether wire was set at 150', and the weather balloon was filled with helium to a diameter of approximately 6'. The mass of all parts of the system was measured at 3.1kg.

All equipment was assembled on the ground. Upon releasing the balloon from the ground, a nearby tree branch breached the tarp and penetrated the weather balloon. All of the helium was released from the balloon, and it was destroyed. The test failed.

Test 2

The two tethers were mounted with the cinder blocks on 20' high rooftops approximately 20 meters apart. Upon release, the balloon successfully elevated the system to about the height of the rooftops. However, frequent wind gusts of about 10 mph caught the exposed flaps of the tarp and created a sail effect, pushing the balloon downwards. The test failed.

Test 3

The system was tested under the same conditions as test 2. The tarp was modified in this test by securing most of the exposed flaps closer to the balloon to prevent air from dragging on the flaps. Again, wind gusts around 8-10 mph were frequent. When tested, the balloon performed similar to test 2: it reached the height of the rooftops. The balloon still experienced similar wind drag, but it was slightly reduced compared to tests 1 and 2.The test failed.

Test 4

In order to test whether the balloon contained enough lift force to lift the platform free from wind interference, the system was moved into a controlled environment (the Fountain Hills High School Gymnasium) with no wind current present. All components were attached to the balloon and it was released. The balloon failed to lift the camera . Test 4 revealed that a 6' diameter helium balloon would not be sufficient to lift the weight of the platform and the additional components in the system (tether, carabiners and rope).

Balloon Material Revision

After considering problems encountered with the use of a latex balloon, a new balloon material was considered. We hoped for a material that was more resistant to tear, retained gases better, and had a more durable design. We decided on using a plastic based material, and predicted the mass of the balloon to be about 500 grams greater than that of the latex balloon. We predicted that the balloon would lose 10% of its internal gases every 30 days and that it would have an increased durability and a greater structural strength, eliminating the need of the tarp. The removal of the tarp's mass and the addition of the new balloon's mass was predicted to decrease the net mass of the system. This, we predicted, would then reduce the counteractive forces on the system's lift, making our tests run more smoothly.

Cost of New Equipment

New weather balloon:	$300.00
Tethers:	2 for $30.00
Tether anchor:	$20.00

Test 5

In order to both stabilize during lift as well as make a more efficient tether system, new tether lines were introduced as well as a new anchor. This anchor consisted of two arms with which to place spools on, which would then be unraveled as the balloon lifted into the air. Along with this, a stronger and larger plastic balloon was used in this launch. Both revisions proved to be very useful, a final height of 330 ft was achieved. Pictures were taken from 100, 200, and 300 feet. The pictures showed full areas of the campus and proved to have decent resolution for our purposes.

Conclusions

It is possible to create a cost effective aerial surveillance system with little more than a weather balloon and and the camera itself. The system is extremely effective when monitoring animal movement during the light hours of the day, however, it has its limitations during the night. During this research period we proved that our hypothesis is valid, a cost-effective aerial surveillance system is possible to make, but to make it fully functional during the night additional research must be performed.

Cost of Final System

Cinder blocks:	2 at $2.50
Tether Anchor:	1 at $20.00
Nylon string:	400' at $1.00
Nylon base tether:	2 rolls at $30.00
Foam board:	$3.00
Camera:	$100.00
Carabiners:	5 at $10.00
Plastic weather balloon:	1 at $ 300.00
Tarp:	2 at $30.00
Pulleys:	4 at $4.00
Flashing LED's:	2 at $10.00
Orange flags:	3 at $4.00
Duct tape:	2 rolls at $5.00
Total:	$697.00

Applications

Among the application we outlined when brainstorming for this project (tracking javelina movement) other possibilities for further use include monitoring: urban development, the destructive effects of development on natural habitats, migration patterns of animals, or any experimental research which requires or could greatly benefit from an aerial vantage point.

SPECIFICATIONS OF SURVEILLANCE SYSTEM

Balloon

Camera

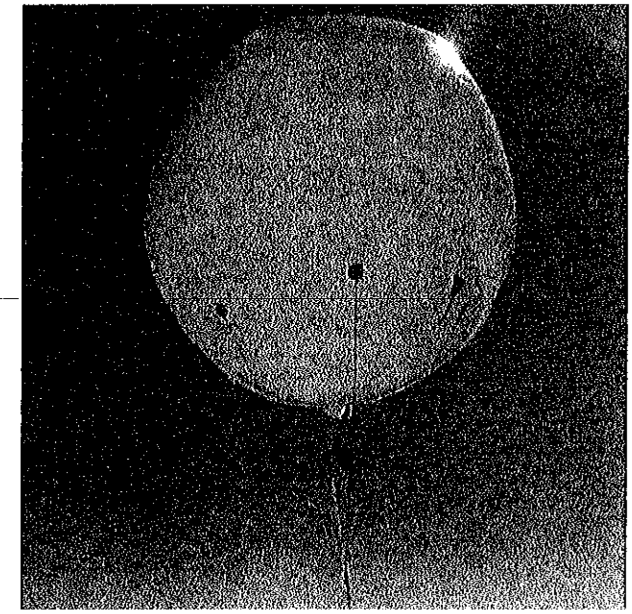
Platform

Carabiner

Tether

Lighting System

Balloon



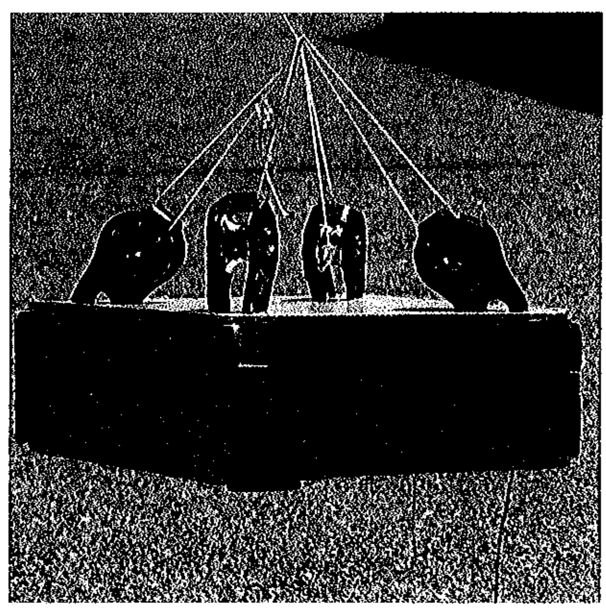
Prototype Balloon -
Material: Latex
Diameter: 8 feet
Weight - 0.5 lbs

Current Model Balloon -
Material:Plastic Base
Diameter: 8 feet
Weight ~ 5.4 lbs.

Camera

Model Name - Day 6 Plotwatcher Time Lapse Video Camera
Weight ~ 2 lbs.

Platform



Camera Holding Box -
Material - Foam Board
Weight - 0.5 lbs

Base -
Material - Cinder blocks (2)
Weight - 25 lbs. per block

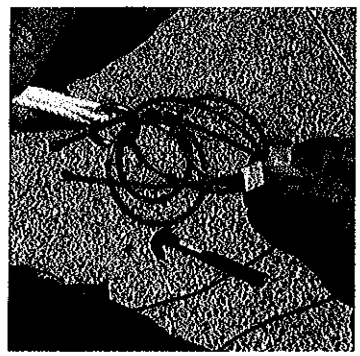
Carabiner

Material - Metal
Weight - 0.4lb per Carabiner

Tether

Prototype Tether -
Material - Fishing Wire
Weight - 1lb per spool

Current Tether -
Material - Nylon-baseWeight - 1.5 lbs per spool



Lighting System

Model - Solar Powered LED's
Power Source - Sun
Weight - 1lb