Utilizing occupancy models to compare effectiveness of dogs and humans at detecting the invasive spotted lanternfly

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Spotted Lanternfly
*Lyccorma delicatula*

Arrived in PA in 2014 from Asia as egg masses shipped on stone slabs. Rapidly spread.

Feeds on and damages agricultural species (grapes, apples, hops)

Honey dew excretion and following sooty mold on fruits and leaves causes further damage

Swarms in large numbers and limits outdoor activities
None
Strategy to reduce SLF impacts in NYS involves early detection and rapid response

Yet small populations and egg masses are difficult to find!
Detection Dog Team

Dia: American Field Labrador

Fagen: Belgian Malinois
20 vineyards searched in Jan – May 2021
Survey Methods

20 vineyards & surrounding natural areas (i.e. “forest”)

- Survey Units
  - 12 transects/vineyard ($\bar{x} = 20$ m, range 20-21 m)
  - 12 transects/adjacent forest ($\bar{x} = 26.6$ m, range 17 – 38 m).

- Survey Sub-Units
  - Each vine, pole, or 1-m segment of forest transect

- Repeat surveys: 2x human, 2x dog
- Unlimited search time

**All sites had a known, visible infestation**
Methods: Occupancy Modeling

- Accounts for imperfect detection of organisms in surveys
- Uses presence (1) non-detection (0) data
- 2 Parameters:
  - Probability of occupancy
  - Probability of detection

Field Observation

- You survey an area
- You do not see the species \((y=0)\)
  - Observation Error = perfect detection
- You see the species \((y=1)\)
  - The species is there \((z=1)\)

Biological Reality
Occupancy Methods

Multi-Scale Occupancy model

- Estimate lanternfly occupancy rates with imperfect detection
  - Transects (related to probability of invasion from a source)
  - Subunits (vines, poles, 1m forest segments) nested within transects – related to intensity of infestation

- Estimate detection probability of subunits
  - Dog vs. human
Occupancy Results

Transect-level Occupancy:
- Vineyard = 0.94
- Forest = 0.85

Subunit-level Occupancy:
- Vineyard = 0.47
- Forest = 0.13

(n = 8 sites)
Occupancy Results (Distance to Forest)

- Vineyard transects closer to forest = higher occupancy

44% of SLF egg masses were found within 15 m of the vineyard edge

Detection Results (humans vs. dogs)

- Vineyard: Humans 1.8x better than dogs
- Forest: Dogs 3.4x better than humans
Search Efficiency
Detections/Hour
(D/H)

- Vineyards: Humans more efficient than dogs
  - Humans = 31.4 D/H
  - Dogs = 24.0 D/H
- Forest: Dogs slightly better
  - Dogs = 7.66 D/H
  - Humans = 6.72 D/H
Detection Results (infestation level)

- Infestation: Higher infestation sites had higher detection probabilities
Search Strategy Recommendations

- Search in vineyards close to forest (<~75m)
- Search larger trees near the edges of vineyards, especially trees at higher elevations
- Search metal poles in vineyards
- Use dogs to search vineyards only in early detection
- Employ detection dogs in forest sites where visual detection is challenging for humans (results in >3x greater detection)
Thanks to the vineyards for access

- Blue ridge
- Eagles Rest
- Brook Hollow
- M&M
- Big Creek
- Franklin Hill
- Unionville
- Solieada
- Mount Salem
- Beneduce
- Federal Twist
- Vivat Alfa
- Buckingham Valley
- Wycombe
- Working Dog
- Iron Plow
- Valenzano
- Amalthea
- Autumn Lake
- Blue Cork
Questions?
CAN CANINES HELP PROTECT NEW YORK’S KEY AGRICULTURAL CROPS FROM A NEW PEST?
This tree with many SLF egg masses was a dominant oak next to the edge of a vineyard.
Also flagged & searched transects in surrounding woodlots/landscape
Mantids attacking SLF in vineyards?
Comparison with traditional methods

5x faster finding brown tree snakes
9x more likely than camera traps to detect single bear or bobcat
10x faster finding the first black footed ferret
16x more area searched for black footed ferrets/unit time
36x more likely than hair snares to detect single bear or bobcat
39x more turtles discovered / unit time

Abbreviated References:
8 Goodwin 2010. Invasive Plant Science and Mgmt.
9 Rolland et al. 2006. J. of Cetacean Research and Mgmt.
“Prime real estate” for SLF eggs on grapevines

- Undersides of cordons
- Tight spaces between trunks and supports
- Trunk bases, especially if there are weeds/foliage providing some cover and if the trunk is leaning
Undersides of cordons
Tight spaces between trunks and supports

Cracked wooden post with many eggs inside
Bases of trunks and supports
Check undersides of leaning or fallen trees around the property!

More places to search for SLF egg masses
NY-NJ Trail Conference
Conservation Dogs Program

• Established in 2018 as part of the Lower Hudson PRISM

• Use detection dogs to supplement invasive species early detection and removal activities
  • Be more thorough in our removal activities
  • Move invasive species populations to “eradicated” state sooner

By:
• Finding plants missed during removals
• Extending the boundaries of known infestations

• Target invasive species include Scotch Broom, Slender False Brome, Sticky Sage, Spotted Lanternfly, Oak Wilt and Kudzu
Novelty

There has been no other effort for SLF—or any insect pest—to use modeling to both understand the probability of detecting infestations in agriculturally important areas (e.g., vineyards) and estimating detection probability of dogs and humans.
Multi-Scale Occupancy model

- Estimate lanternfly occupancy rates with imperfect detection
  - Subunits (vines, poles, 1m forest segments) nested within transects
  - Repeat surveys: 2x human, 2x dog

- Estimate transect-level occupancy probability as a function of...
  - Habitat type (Vineyard vs. Forest)
  - Infestation level at the site
  - Interaction between habitat type and infestation level
  - Habitat covariates (Topographic position index, distance to forest for the vineyards)

- Estimate Sub-Unit level occupancy probability as a function of....
  - Same as transect-level + Sub-unit substrate type (vine, metal pole, wood pole, other poles)
Modeling Methods: Detection

Estimate detection probability

- Dog vs. human (observer type)
- 3 humans, 2 dogs (Observer ID)
- Vine vs. pole vs. forest (subunit type)
- Vineyard vs. forest
- Low vs. high infestation level
- Weather covariates (snow, precipitation, wind speed)
Methods: Search Time & Efficiency

**Search Time:** Recorded time to search 12 vineyard and 12 forest transects at each site.

**Search Efficiency** = Expected # of detections across 12 transects/search time

- Linear model estimating mean search time or search efficiency
- Humans vs Dogs a function of:
  - Habitat type (vineyard vs. forest)
  - Infestation level
Search Time & Search Efficiency

Search Time

- Mean Search Time for 12 transects:
  - Vineyards
    Dogs = 1.87 hours
    Humans = 2.44 hours
  - Forest
    Dogs = 2.08 hours
    Humans = 1.3 hours
- Infestation: Dogs took more time at high infestation sites, but humans did not
  - Low infestation in vineyards: Humans slower than dogs
  - Low and high infestation in forest: Humans faster than dogs

Efficiency:

- Vineyards: Humans more efficient than dogs (especially in high infestation sites)
- Forest: Dogs had more detections than humans in forest, but offset by greater search time = similar efficiency to humans
Observer differences

There was variation in detection probability between the three human observers and between the two dogs, but it was not statistically significant.
Conclusions

- Dogs can be more effective than human searchers at detecting SLF egg masses, but that is context specific and requires additional work.

- This study serves as a pilot for how detection dogs and occupancy modeling can be applied to address the complex task of early detection of an invasive species.

- The results can inform search strategies that New York State employs for early detection of SLF by understanding influences of weather and context on detection probability.

- Modelling occupancy of SLF, accounting for the probability of detection using naturally occurring egg masses will establish a framework that will have wide utility for dogs searching for various taxa—whether invasive, threatened, or endangered in diverse habitats and geographic locations.

- Multi-scale occupancy models allow occupancy to be estimated at the transect level and the subunit level (e.g., vines, poles, forest segment) and detection to vary as a function of observer (dog, human), infestation level, and weather covariates. The model framework could be applied to any invasive species.
Where to search for SLF egg masses

Larger trees near the edges of vineyards for SLF egg masses, especially trees at higher elevations
44% of SLF egg masses were found within 15 m of the vineyard edge and a significantly lower proportions of egg masses (12%) were found on vines located 75 m from the vineyard block edge.

Search Time & Search Efficiency

**Search Time**
- Mean Search Time for 12 transects:
  - Vineyards
    - Dogs = 1.87 hours
    - Humans = 2.44 hours
  - Forest
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More detections at high infestation
Example Transect Layout
Study Objectives

Utility of detection dogs as an early detection method for SLF

Goals:
1) Compare the efficacy of human observers and detection dogs to detect SLF egg masses
2) Model the probability of occurrence of SLF
3) Identify environmental factors that influence a dog or humans ability to detect SLF (skipping today)
4) Pilot optimal search strategies based on our findings
Hypotheses

1) Occupancy higher closer to forest

2) Infestation-level matters
   - Occupancy should be higher with higher lanternfly infestation level at a site
   - Detection probability of humans and dogs should be higher at sites with higher infestation levels (more lanternfly eggs available for detection)

3) Detection probability of humans vs. dogs
   Humans use visual search and dogs use olfactory:
   - Human and dogs equal in vineyards
   - Dogs better in forest
Timeline sightings, infestations, and quarantines

- **2014**: Initial infestation: Berks County, PA.
- **2017**: First New York sighting.
- **2018**: 7 counties in NY — all hitchhikers; no populations.
- **2020**: Populations found in Staten Island, and Ithaca, NY.
- **2021**: Populations expanded in NY, New population near Binghamton, NY. Infestations detected in Massachusetts and Indiana.

Short- and long-term solutions being utilized and under development....

• New pesticides and strategic “trap trees”
• Physical barriers (netting)
• Sticky bands and other physical removal
• Biological control
  • Pathogens
  • Parasitic wasps

Currently no long-term solution available
Seeking the most effective tool for early detection......
Detection Results (Vineyards)
Search Time

**Search Time**
- Mean Search Time for 12 transects:
  - Vineyards
    - Humans = 2.44 hours
    - Dogs = 1.87 hours
  - Forest
    - Dogs = 2.08 hours
    - Humans = 1.3 hours

**Infestation:**
- Dogs took more time at high infestation vs moderate infestation sites
- Humans search similar time regardless of infestation level
Detection Results (Wind)

Dog detection probability in vineyards greater with higher wind speeds
Topographic Position Index & Occupancy

0 = Flat
Large positive = ridge or hill
Large negative = valley bottom
Detection Results (snow)
What is Occupancy Modeling?

- Accounts for imperfect detection of organisms in surveys
- Uses presence (1) absence (0) data
- 2 Parameters:
  - Probability of occupancy
  - Probability of detection

Field Observation = 4 sites
Biological Reality = 11 sites
Detection Results

- Infestation: highly infested sites have higher detection probability than moderate infestation
- Vineyard: Humans better than dogs
- Forest: Dogs better than humans

Per Visit Detection Probability

Unit of detection: vine, pole, forest
Summary/Conclusions

- **Infestation level:**
  - Higher detection probability of SLF at higher infestation sites

- **Substrate type:**
  - Vineyards higher occupancy than forest
  - Metal poles higher occupancy than vines

- **Humans vs. Dogs**
  - Humans more efficient in vineyards than dogs (at high to moderate infestations; humans can use visual search)
  - Dogs more efficient in forest (expect even greater efficiency of dogs vs. humans in low infestation scenarios).

- Modelling occupancy of SLF offers a framework with utility for dogs searching other taxa