# Eastern gray squirrel *Sciurus carolinensis*

# The original “gray squirrel” was melanic

The black squirrel was very destructive to crops in New York, the gray arriving with settlement.[73] In the Genesee River region, black and red squirrels were common in 1804 but the gray was rare.[74] Some information on the disappearance of the black squirrel at Le Roy, New York, is given by Comstock.[75] This phase declined from about 90 percent to 2.5 percent from about 1850 to the period 1884-90. Dr. L. F. Hawley informed me that the ratio of black to gray was three to one at his home, Salamanca, New York, in 1900 and that on going to Ithaca only the gray was to be found.

But melanics have not completely disappeared…

Urban and elsewhere

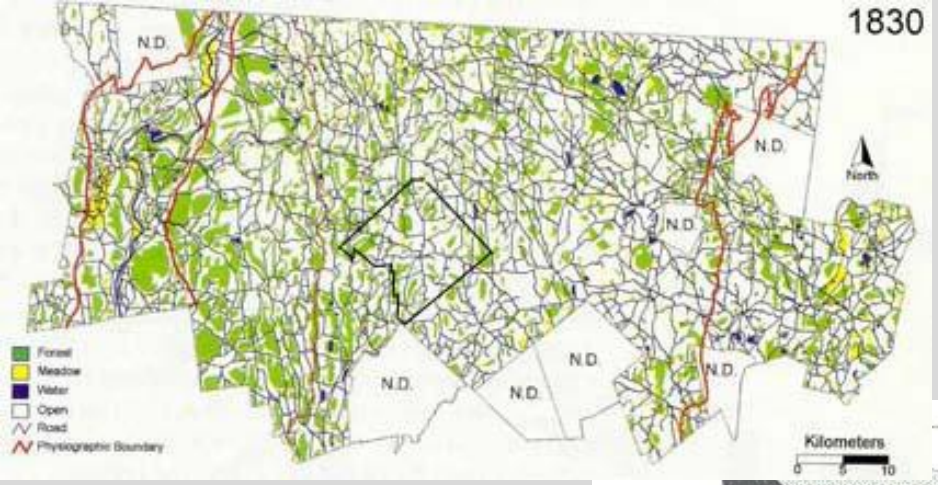
Urban

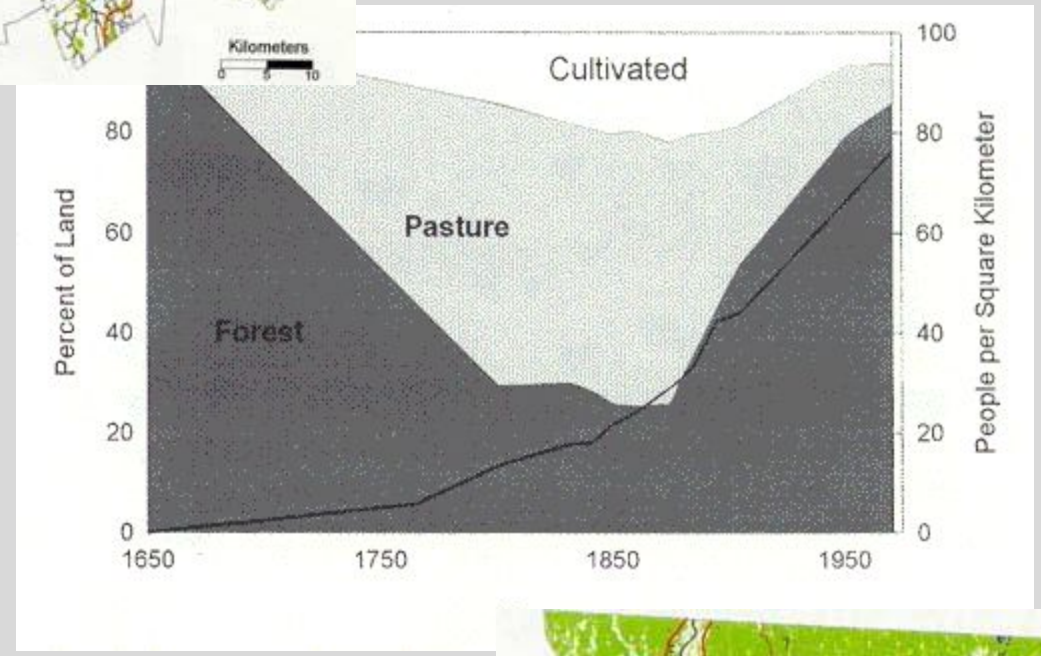
# Squirrel demography facts

- 90% rural squirrels killed by predators including hunters
  - 10% to disease, starvation etc.
- 90% urban squirrels killed by cars
  - 10% to predators, disease etc.

# Hunting hypothesis

- Heavy hunting
- Hunters seem to prefer melanic squirrels
- No hunting in cities
- Are gray morphs more cryptic in contemporary forests?


1830
N.D.
N.D.
N.D.
N.D.
N.D.
N.D.
North
Forest
Meadow
Water
Open
Road
Physiographic Boundary
Kilometers
0 5 10


Cultivated
Pasture
Forest
Percent of Land
People per Square Kilometer
0
20
40
60
80
100
1650
1750
1850
1950


1985
North
Forest
Meadow
Water
Open
Physiographic Boundary
Kilometers
0 5 10

Hypotheses:

- melanics more cryptic in old growth than grays
- melanics more conspicuous in second growth forest

# Road-kill hypothesis

FEATURED

# No one seriously injured in squirrel-related wreck

By From staff reports May 23, 2017 (10)

No one was seriously injured Tuesday in a single-vehicle wreck on Cokesbury Road.

CONOR HUGHES | INDEX-JOURNAL



*"A man in Pennsylvania lost control of his car, crashing into a parked vehicle, claiming it was all because he was trying to avoid hitting a squirrel."*

# Key facts…

- **“Road kill” is by far the primary mortality agent of urban squirrels**.
- Only  a small proportion (< 3 %) of car drivers evidently intentionally swerve to kill small wildlife on roads
  - vast majority swerve to avoid them.
- Which morph is more visible / avoidable to drivers?

# Which are more “avoidable”?

How do you test these hypotheses?

# Fitness in forests…

# How do you measure “fit” to “visual environment”?

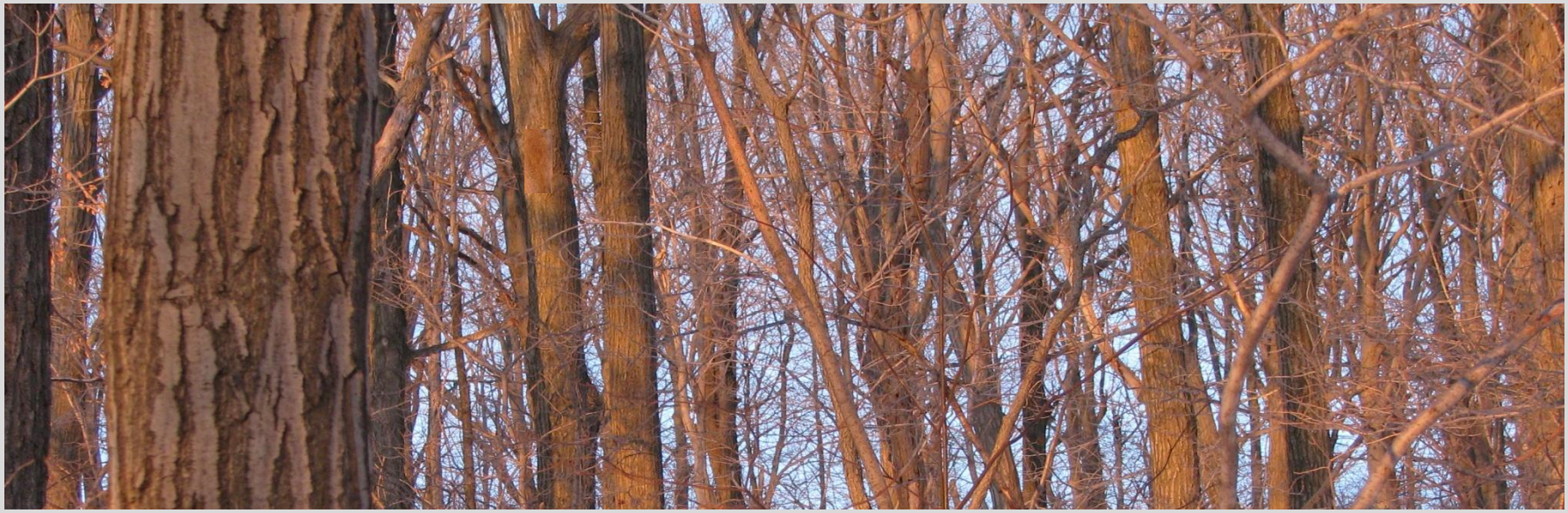
- “Crypsis” or conspicuity
- Not so easy to measure!
- Need both morphs against background in same image
  - The only way to control all factors!
- Fortunately YOU are the predator so your visual system is reliable

# 100b

# 100g

# 100b

# 100g



# 1g

# 3g

# 9g

# 10b

SquirrelMapper: Squirrel Hunt - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.squirrelmapper.org/squirrel_hunt

Most Visited Getting Started Latest Headlines http://webmail.esf.ed...

Squirr... Evolution M... Conservatio... Altai Pilgrim Google CREES: Gra... — Citizen Sc... Call for Appl... About

# Squirrel Mapper

*Measuring evolution in action in urban and rural landscapes.*

ESF NSF

- Home
- Scientific question
- View records
- Instructions
- Add data
- Who's reporting?
- Morph geography
- *"Squirrel Hunt"*
- FAQ
- Logout
- For Teachers
- About

## "Squirrel hunt" to measure natural selection pressures.

**Just how conspicuous are gray and black squirrels in old growth, second growth and urban forests?**


In this "Squirrel hunt" activity you will be a pseudo-hunter hunting for pseudo-squirrels. In doing so you will directly measure the selection pressures on black and gray squirrels in second growth forest, old growth forest, and urban environments. Estimates of selection pre... different colored squirrels will be provided at the end of the exercise.

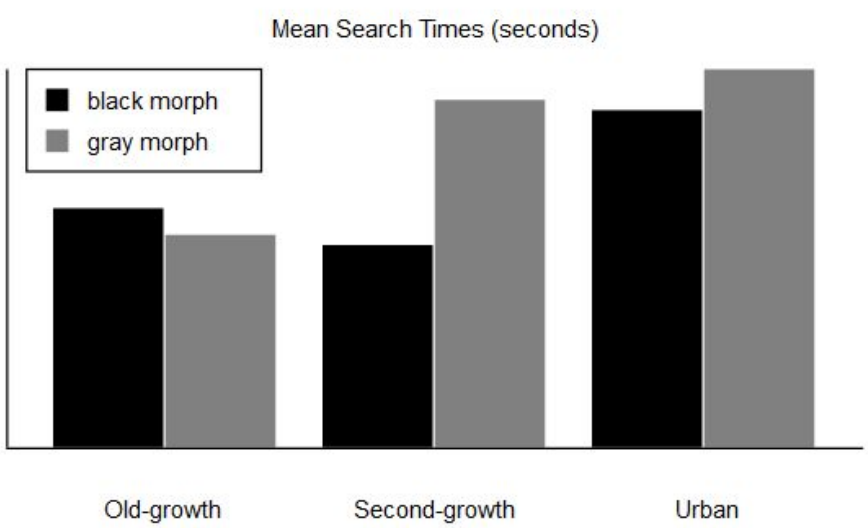
Instructions Start Analyze About

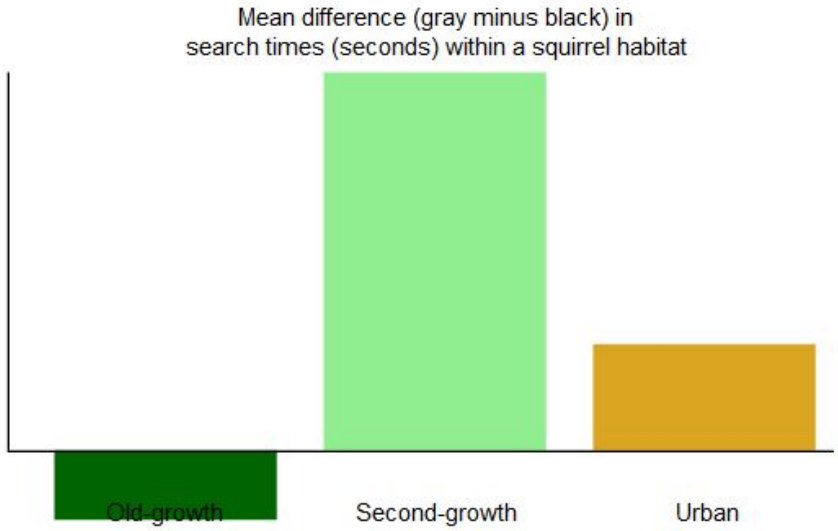
Dell ControlPoint

Rosa-net connected. Would you like to create a location profile for this technology?

# Jan 2018 data

Explanation of analysis | Everyone's data | Your data

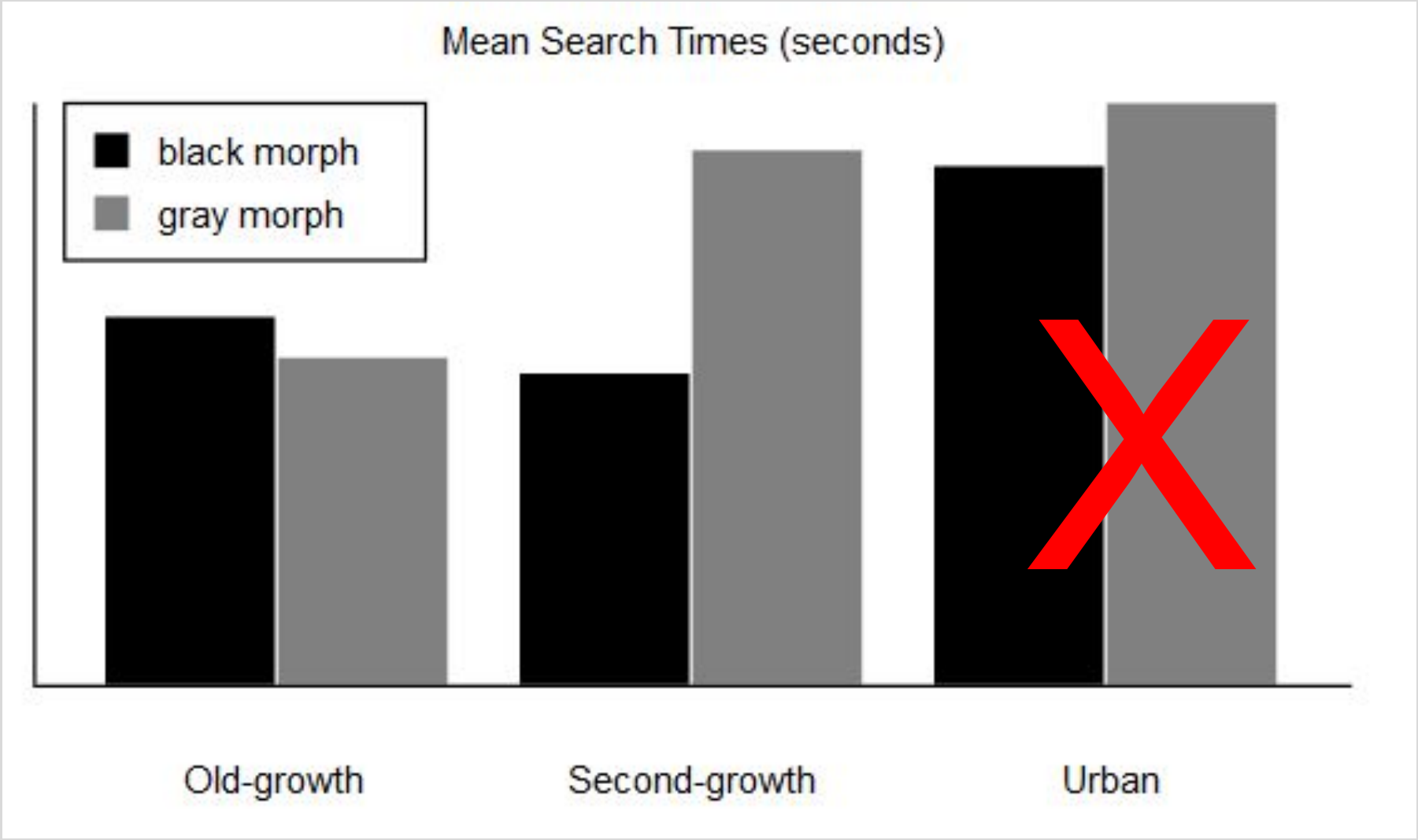


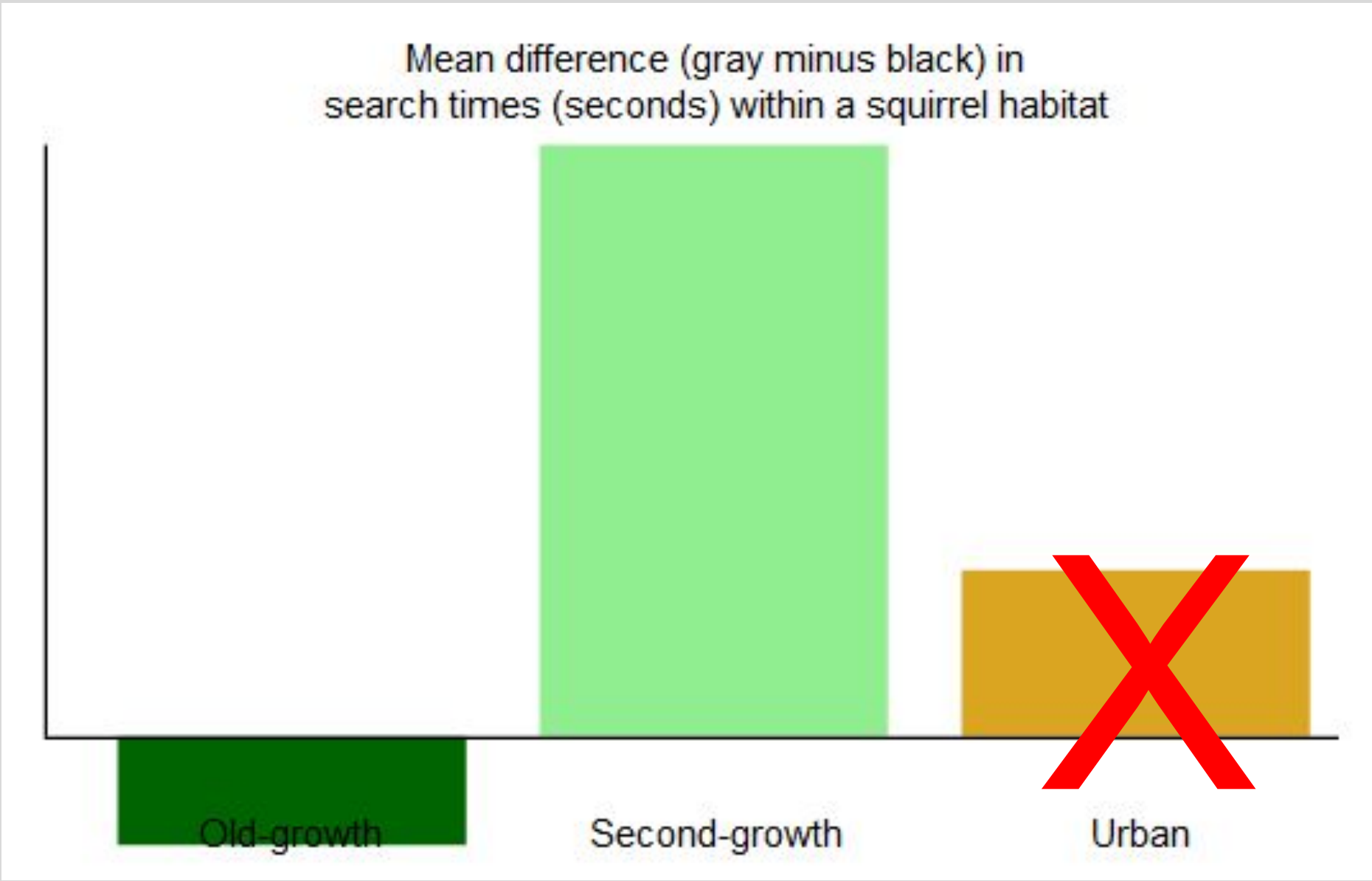




In this analysis in old-growth forest the confidence interval does not include zero; therefore, we conclude that the gray morph took less time to find than the black morph. Following the same reasoning, in second-growth forest the gray morph took more time to find than the black morph. In urban forest the gray morph took more time to find than the black morph.

Mean Differences Between Search Times (seconds)

| Forest | Lower 95% Confidence Interval | Mean Difference | Upper 95% Confidence Interval | Sample Size |
|---|---|---|---|---|
| old-growth | -0.35 | -0.31 | -0.27 | 28,079 |
| second-growth | 1.59 | 1.67 | 1.75 | 27,505 |
| urban | 0.35 | 0.47 | 0.60 | 27,166 |


Mean Search Times (seconds)
black morph
gray morph
Old-growth
Second-growth
Urban


Mean difference (gray minus black) in
search times (seconds) within a squirrel habitat
Old-growth
Second-growth
Urban

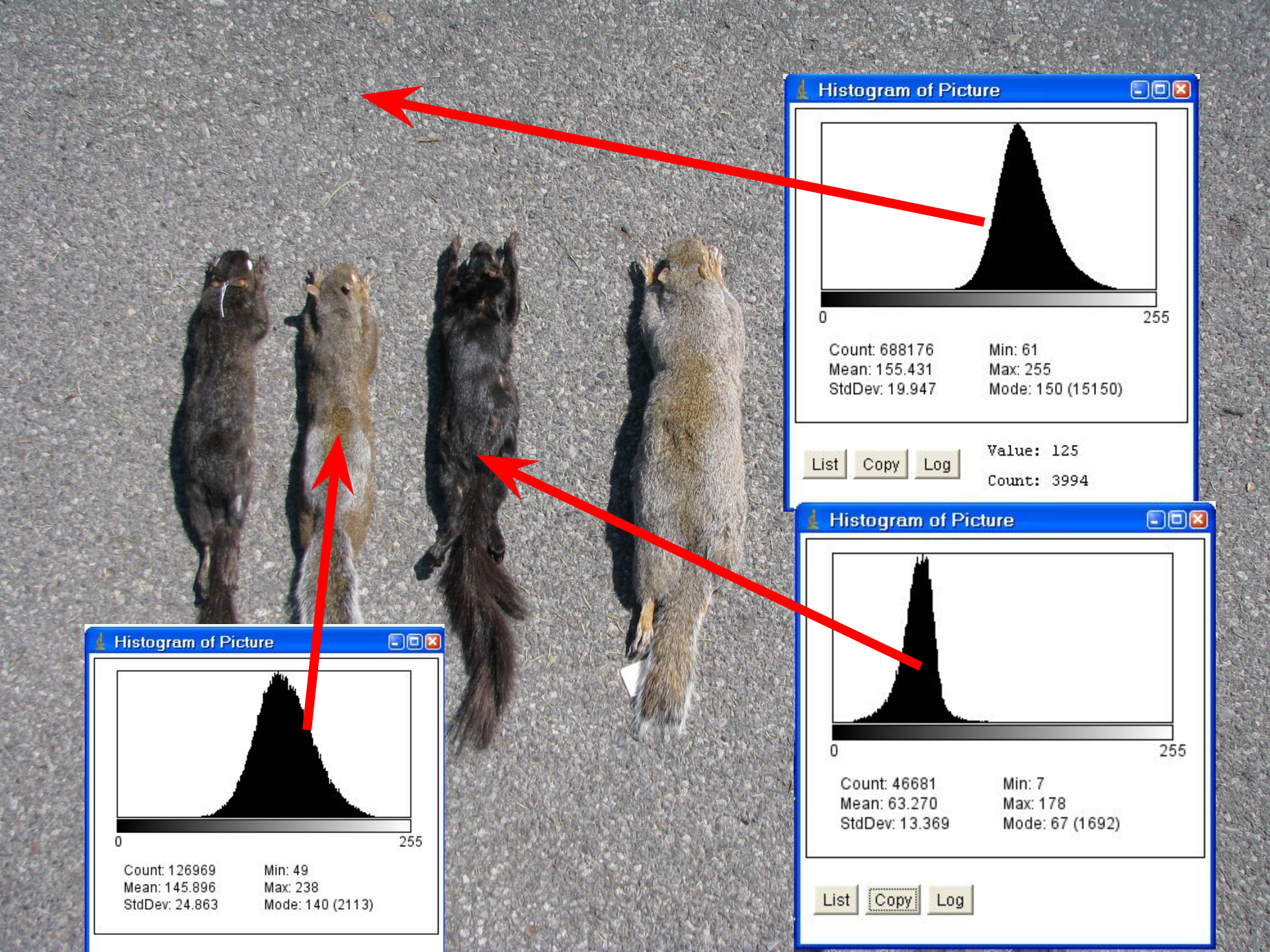
# Search times: (gray - melanic)

| Mean Differences Between Search Times (seconds) | | | | |
|---|---|---|---|---|
| **Forest** | **Lower 95% Confidence Interval** | **Mean Difference** | **Upper 95% Confidence Interval** | **Sample Size** |
| old-growth | -0.35 | -0.31 | -0.27 | 28,079 |
| second-growth | 1.59 | 1.67 | 1.75 | 27,505 |
| urban | 0.35 | 0.47 | 0.60 | 27,166 |

# Road-kill hypothesis

# How do you measure conspicuousness to drivers?

…who seek to avoid running over squirrels…


Histogram of Picture
0
255
Count: 688176
Mean: 155.431
StdDev: 19.947
Min: 61
Max: 255
Mode: 150 (15150)
List
Copy
Log
Value: 125
Count: 3994
Histogram of Picture
0
255
Count: 46681
Mean: 63.270
StdDev: 13.369
Min: 7
Max: 178
Mode: 67 (1692)
List
Copy
Log
Histogram of Picture
0
255
Count: 126969
Mean: 145.896
StdDev: 24.863
Min: 49
Max: 238
Mode: 140 (2113)

# Image J

- https://imagej.nih.gov/ij/
- Load image into ImageJ
  - Outline object
  - Create histogram of image intensities
  - Copy values
  - Paste into Excel worksheet provided
- In worksheet
  - Determine proportion of pixels of total in each category
  - Determine **absolute** difference between proportions in each intensity class for each squirrel versus background
  - Average **absolute** differences across all intensity categories
- Which values are smaller, i.e., more similar? Gray to pavement or melanic to pavement? By what factor?

# Spreadsheet for analyzing crypsis on roads

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pavement | | | Gray Squirrel | | | | Black Squirrel | | | |
| 2 | total pix: | 89040 | | total pix: | 102708 | | ***0.001531537*** | total pix: | 50052 | | ***0.006893696*** |
| 3 | Hue | Pixels | Fraction | Hue | Pixels | Fraction | difference | Hue | Pixels | Fraction | difference |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 4E-05 | 3.99584E-05 |
| 7 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| 8 | 4 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 2 | 4E-05 | 3.99584E-05 |
| 9 | 5 | 0 | 0 | 5 | 1 | 9.74E-06 | 9.73634E-06 | 5 | 14 | 0.00028 | 0.000279709 |
| 10 | 6 | 2 | 2.25E-05 | 6 | 0 | 0 | 2.24618E-05 | 6 | 38 | 0.000759 | 0.000736749 |
| 11 | 7 | 0 | 0 | 7 | 1 | 9.74E-06 | 9.73634E-06 | 7 | 84 | 0.001678 | 0.001678255 |
| 12 | 8 | 0 | 0 | 8 | 2 | 1.95E-05 | 1.94727E-05 | 8 | 159 | 0.003177 | 0.003176696 |
| 13 | 9 | 0 | 0 | 9 | 0 | 0 | 0 | 9 | 220 | 0.004395 | 0.004395429 |
| 14 | 10 | 0 | 0 | 10 | 0 | 0 | 0 | 10 | 301 | 0.006014 | 0.006013746 |
| 15 | 11 | 0 | 0 | 11 | 2 | 1.95E-05 | 1.94727E-05 | 11 | 353 | 0.007053 | 0.007052665 |
| 16 | 12 | 0 | 0 | 12 | 2 | 1.95E-05 | 1.94727E-05 | 12 | 342 | 0.006833 | 0.006832894 |

# Putting it all together

# Projecting morph frequencies

- $W_{Aa}$, $W_{Aa}$, $W_{aa}$ are *relative fitnesses* of each genotype
- p = frequency of the "p" allele

$$p_{t+1} = (p_t)\frac{p_t w_{AA} + q w_{Aa}}{p_t^2 w_{AA} + 2 p_t q_t w_{Aa} + q_t^2 w_{aa}}$$

- What are fitness of the three genotypes?

# The three genotypes:

- Melanic is dominant
- Gray is recessive
- So…
- AA = melanic = $p^2$
- Aa = melanic = 2pq
- aa = gray = $q^2$

# Calculating relative fitnesses

see: *Spreadsheet for predicting evolutionary trends*
***(use current values from the website and your own calculations – not these)***

| | Time to find (s) | | Ave diff. / avoidability |
|---|---|---|---|
| | Old Growth | Second Growth | Urban (Road) |
| $W_{AA}$ = Black | 2.74 | 2.37 | 0.006951 |
| $W_{Aa}$ = Black | 2.74 | 2.37 | 0.006951 |
| $W_{aa}$ = Gray | 2.47 | 4.01 | 0.001499 |
| Maximum: | 2.74 | 4.01 | 0.006951 |
| | Relative fitnesses: | | |
| $W_{AA}$ = Black | 1 | 0.591022 | 1 |
| $W_{Aa}$ = Black | 1 | 0.591022 | 1 |
| $W_{aa}$ = Gray | 0.90 | 1 | 0.21568 |

**Ignore urban forests – can't hunt there anyways…**

# Project into future:

$$p_{t+1} = (p_t)\frac{p_t w_{AA} + q w_{Aa}}{p_t^2 w_{AA} + 2 p_t q_t w_{Aa} + q_t^2 w_{aa}}$$

| | Old Growth | Second Growth | Road |
|---|---|---|---|
| WAA | 2.74 | 2.37 | 0.006951 |
| WAa | 2.74 | 2.37 | 0.006951 |
| Waa | 2.47 | 4.01 | 0.001499 |
| | 2.74 | 4.01 | 0.006951 |
| | | | |
| WAA | 1 | 0.5910224 | 1 |
| WAa | 1 | 0.5910224 | 1 |
| Waa | 0.901459854 | 1 | 0.21568 |
| | | | |
| | p | p | p |
| 0 | 0.50 | 0.50 | 0.50 |
| 1 | 0.51 | 0.43 | 0.62 |
| 2 | 0.52 | 0.35 | 0.70 |
| 3 | 0.54 | 0.27 | 0.75 |

Start with alleles equally likely or p = q = 0.5

=B13*((B13*B$8+(1-B13)*B$9)/(B13^2*B$8+2*B13*(1-B13)*B$9+(1-B13)^2*B$10))

# Trends, where p = fraction alleles melanic:


P




Years

# Next Weds

- Complete the “squirrel hunt” exercise
  - We will use the data current Weds 1/7/2018
- Download the squirrels-on-road image
  - Import to ImageJ
  - Cut-and-paste hue values to spreadsheet
- Explore allele frequency projection

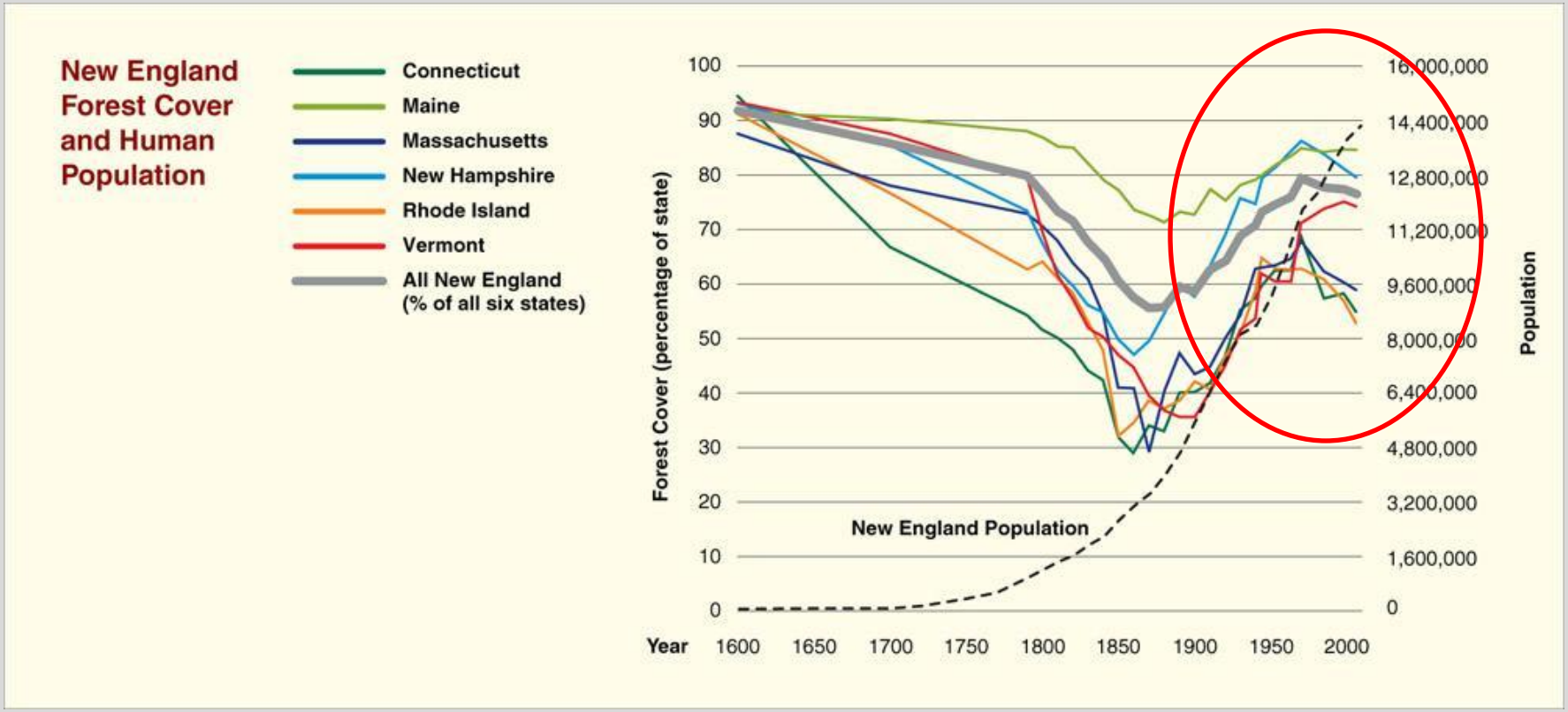
*For your Abstract:*

# The Future of the “gray squirrel”…

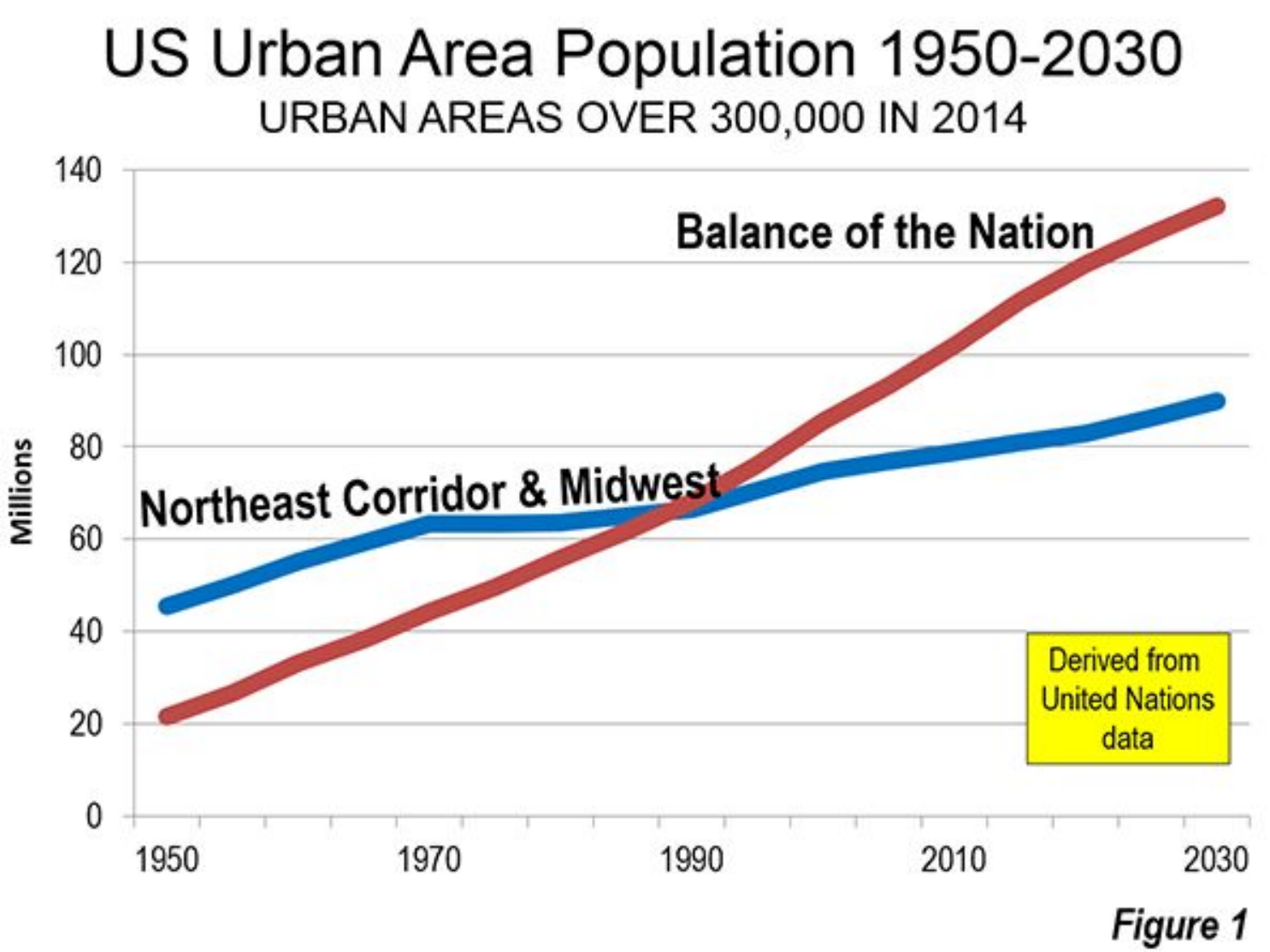
What will it bring?

# Changes in land use?

- Aging of forests…
  - Recovery of old growth?
  - At least some of the forest?



# Urbanization & roads…



# Hunting


Annual U.S. Hunting License Sales
18,000,000
17,000,000
16,000,000
15,000,000
14,000,000
13,000,000
12,000,000
11,000,000
10,000,000
1958
1960
1962
1964
1966
1968
1970
1972
1998
2000
2002
2004
2006
2008
2010
2012
Source: U.S. Fish and Wildlife Service

# Your Abstract


- What will future bring?
  - Urban areas expanding…road mortality will increase
  - Hunting declining
  - Forests changing
    - second growth to old growth
    - Mature forest reverts to younger forest
- Why do you conclude this?
  - Base your conclusion on your predictions
- **Monday of next week due**
  - **Weds available for further questions**