On the front lines of observing change: Biodiversity specimen collectors as the Anthropocene’s outlier detectors

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Change in the Anthropocene

Biodiversity loss

- Dirzo et al. 2014

Phenological shifts

- Miller-Rushing and Primack 2008

Invasive species

- Mack et al. 2000
Building networks for critical early detection

National and International Efforts

Citizen Science
Biodiversity specimen collectors
Collectors can provide rapid detection

- Collectors are regularly in the field
- Collectors recognize patterns and norms through:
  - Personal experience
  - Examination of reliable resources (e.g., flora)
  - Communication with other experts
Rapid detection using outliers

Types of outliers
- Phenological
- Distributional
- Morphological
- Ecological
- Behavioral
- …
Outliers may be indicators of change

- Hybridization
- Distributional changes
  - Exotic species
  - Native species
- Phenological shifts
- Environmental degradation
Collectors can play a critical role in detection and documentation of change. 

but

Are they empowered to do so?
Hypothesis:

Effective Outlier Detection and Documentation

- Ability to detect outliers
- Means to document outliers
- Means to report outliers
- Culture of outlier documentation

Yes
Methods

- Distributed an 18-question survey throughout the collecting community
  - Listservs (e.g., NHCOLL-L, HERBARIA, ECN-L)
  - Natural Sciences Collections Alliance groups
  - iDigBio social media
Survey Responses

- Plants: 55
- Insects: 50
- Fungi: 39
- Algae: 18
- Other: 15
- Mammals: 13
- Fish: 7
- Marine invertebrates: 6
- Amphibians: 5
- Birds: 4
- Fossils: 10
- Marine invertebrates: 6
- 222 total
Survey Responses

Number of Responses vs. Number of Years Collecting

- 0-5 years: 20 responses
- 6-10 years: 30 responses
- 11-15 years: 40 responses
- 16-20 years: 20 responses
- 21-25 years: 10 responses
- 26-30 years: 10 responses
- 31+ years: 80 responses
Effective Outlier Detection and Documentation

- Ability to detect outliers
- Means to document outliers
- Culture of outlier documentation
- Means to report outliers
Effective Outlier Detection and Documentation

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Awareness

Q: As a collector, do you view yourself as being on the front lines of observing and documenting change in Earth's biota?

<table>
<thead>
<tr>
<th>Yes (49%)</th>
<th>Somewhat (31%)</th>
<th>No (13%)</th>
<th>Not sure / undecided</th>
</tr>
</thead>
</table>

Culture
## Training

<table>
<thead>
<tr>
<th>Literature</th>
<th>On the job training</th>
<th>Not taught or self taught</th>
</tr>
</thead>
</table>

**Culture**
Training: Literature Search

- No mention of outlier detection in the collections manuals and literature that we could find
Effective Outlier Detection and Documentation

Ability to detect outliers

Means to document outliers

Culture of outlier documentation

Means to report outliers
Where do collectors document outliers?

- Specimen label: 60%
- Field notes/journals: 50%
- Database field: 40%
- Not noted: 20%
- Publication: 10%
- Other: 5%
- Personal notes: 5%
- Report: 5%

Percent of Survey Respondents
How do collectors document outliers?
Collectors lack the protocol and semantics to document outliers in accessible ways.
Effective Outlier Detection and Documentation

- Ability to detect outliers
- Means to document outliers
- Means to report outliers
- Culture of outlier documentation
- Ability to detect outliers
Where do collectors report outliers?

- Close colleagues
- Experts on the taxon
- Journal article or formal report
- Land managers or park staff
- Government agencies
- Enthusiast groups
- Not likely to report
- Online community resources
- Other
Why don’t collectors report outliers?

- Don’t consider it important (12%)
- Lack of standard protocols (30%)
- Lack of means for documenting (20%)
- Lack of mechanism for reporting (17%)
- Lack of time (47%)
Recommendations

Effective Outlier Detection and Documentation

- Ability to detect outliers
- Means to document outliers
- Means to report outliers
- Culture of outlier documentation

- Development of cyberinfrastructure to support rapid reporting to stakeholders
- Development of community protocols and semantics
- Campaign for collector awareness, training, and protocols
Acknowledgements

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Precedent

Culture

IDigBio Integrated Digitized Biocollections

abnormal atypical

687 1,103

2,327

Nymphalidae: Limenitidinae
Limenitis melanie
(H. W. Bates, 1864)
61.20

http://hasbrouck.asu.edu/imglib/seinet/DES/DES00064/DES00064272_lg.jpg

http://storage.idigbio.org/wtu/mycology/WTU-F-005/WTU-F-005694_L01_lg.jpg

http://mczbase.mcz.harvard.edu/specimen_images/ent-lepidoptera/images/2011_08_16/IMG_095699.JPG

http://arctos.database.museum/media/10483961?open

64,015,275 records
The bar chart shows the percent of responses for different types of outliers. The categories are:

- Very often
- Often
- Occasionally
- Rarely
- Never

The types of outliers are categorized as:

- Morphological
- Anatomical
- Phenological
- Distributional
- Behavioral
- Ecological
- Genetic
- Other

The chart indicates the percentage of responses for each type of outlier, with darker bars representing higher percentages.