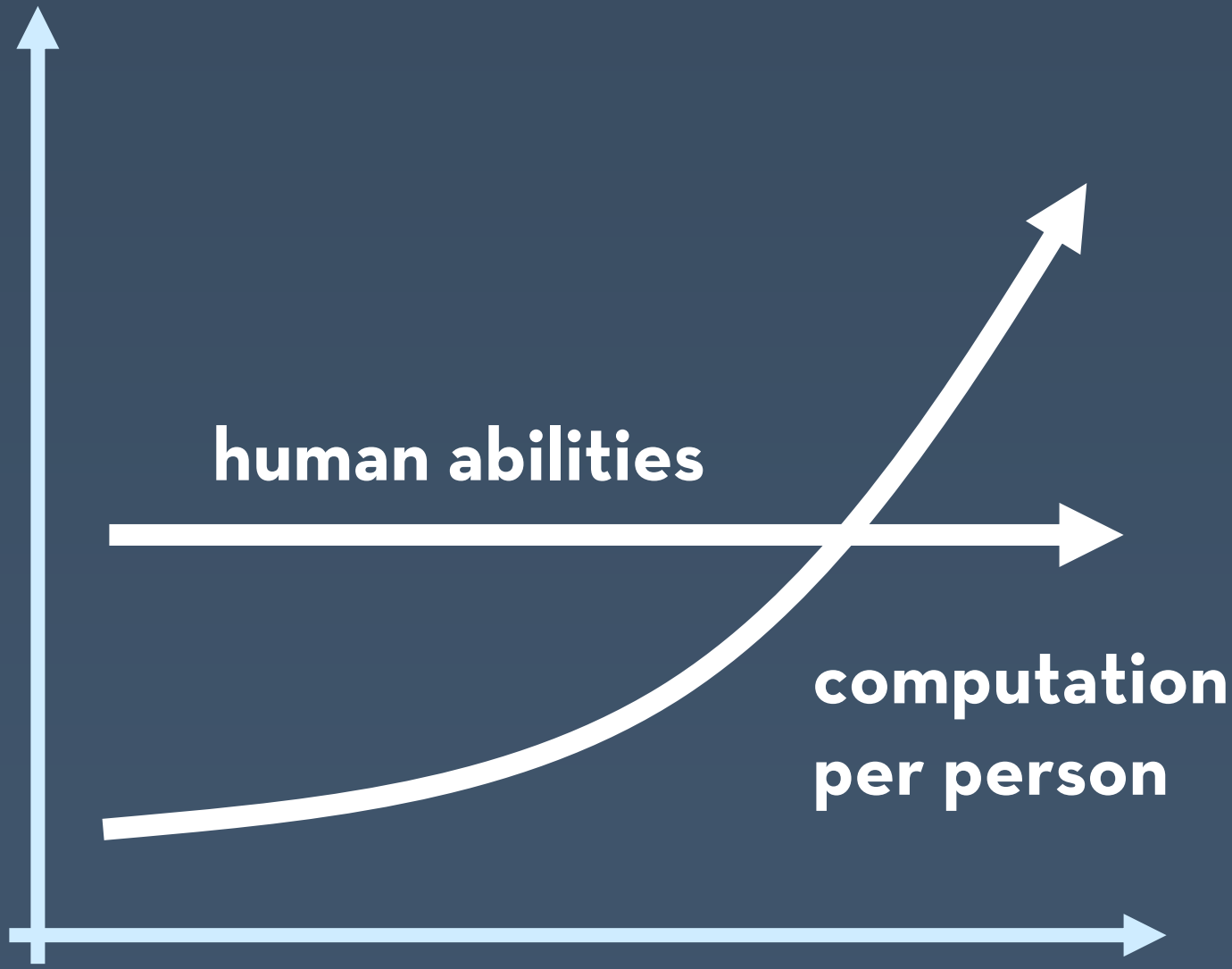
STANFORD HCI GROUP

ButterflyNet

a mobile capture and access system for field research

Scott Klemmer · BERKELEY · 15 March 2006

[O’Sullivan]


human abilities
computation
per person

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

—Mark Weiser, 1991

Ubiquitous & Pervasive Computing

Why Bodies Matter

themes for interaction design

Making progress

building a culture of prototyping

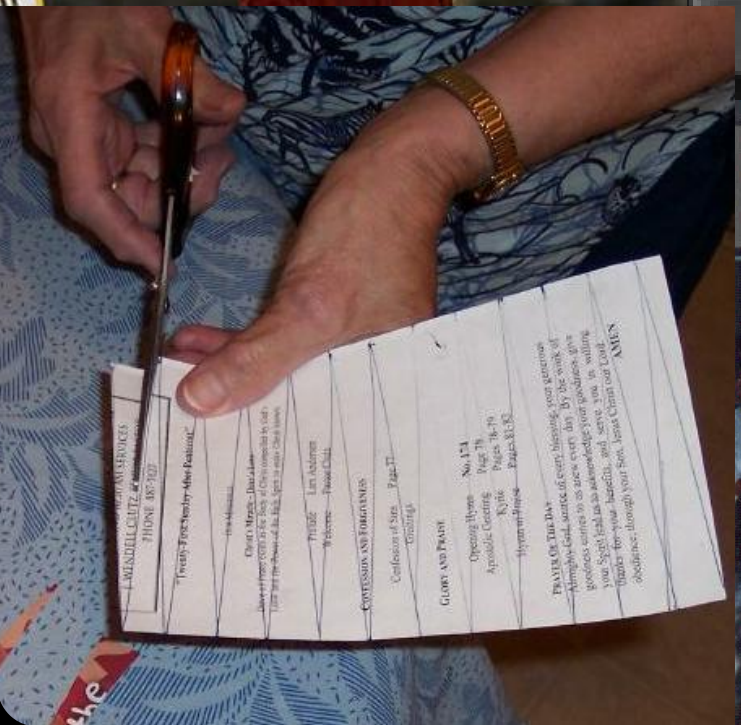
Opportunities

research into design tools

Thinking Through Doing

Thinking Through Doing

Performance



Performance

Visibility

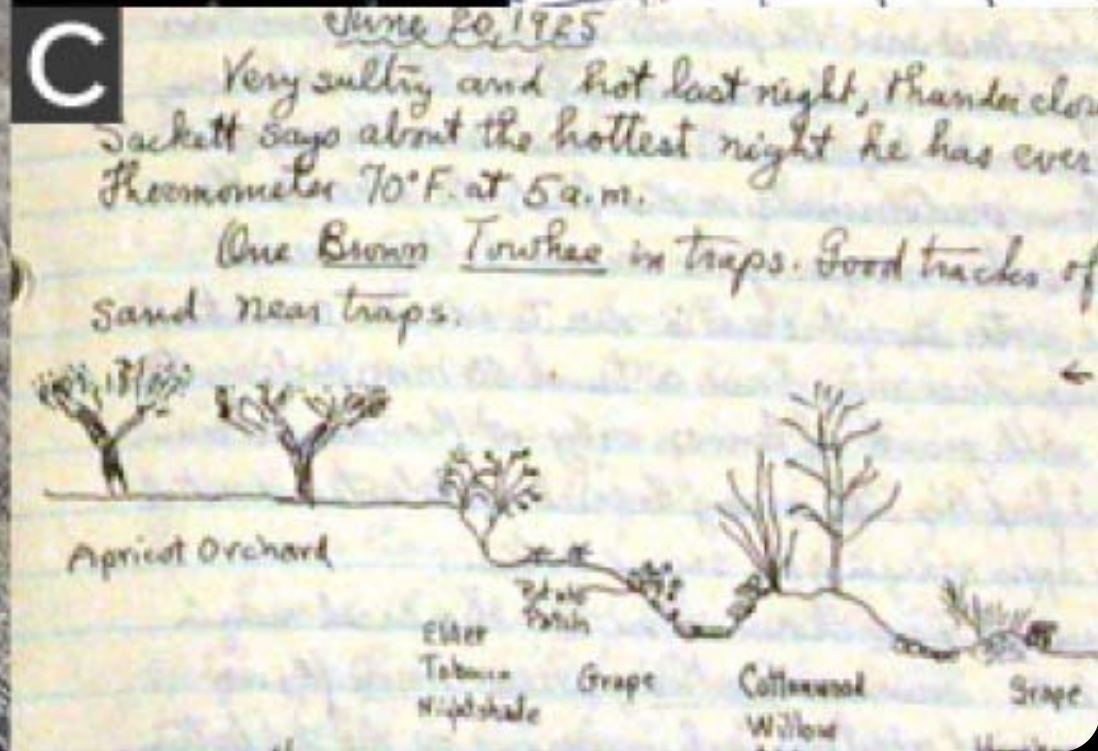
Visibility

Thick Practice

Thick Practice

B

C



Ubiquitous & Pervasive Computing

Why Bodies Matter

themes for interaction design

Making progress

a culture of prototyping

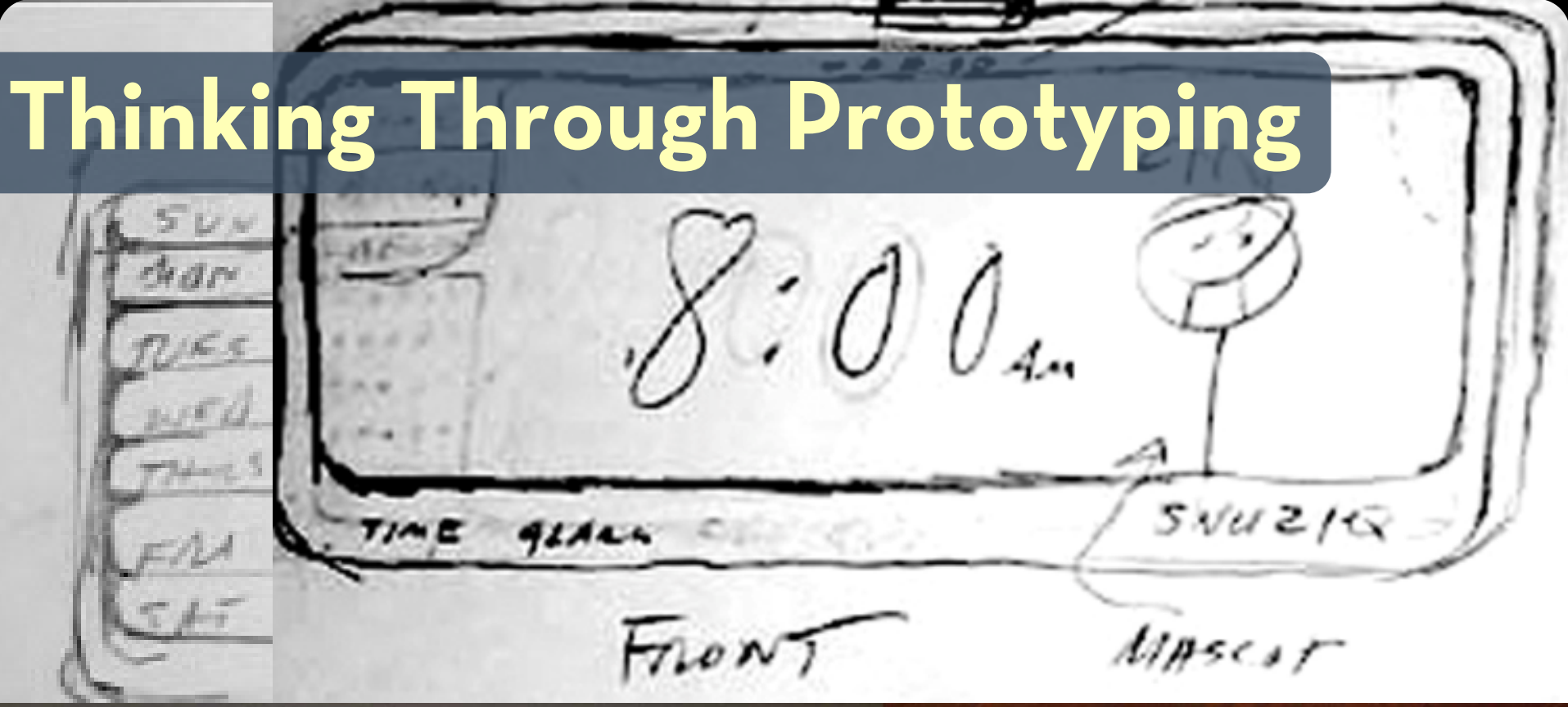
Opportunities

research into design tools

“Organizations manage themselves by managing their prototypes”

—Michael Schrage

Thinking Through Prototyping



Prototypes

Approximations of a product along some dimensions of interest

Goal is *not* artifact – it's feedback

- Personal
- Design team
- Usability
- Clients

Structures innovation, collaboration, and creativity

Three Distinct Prototype Genres

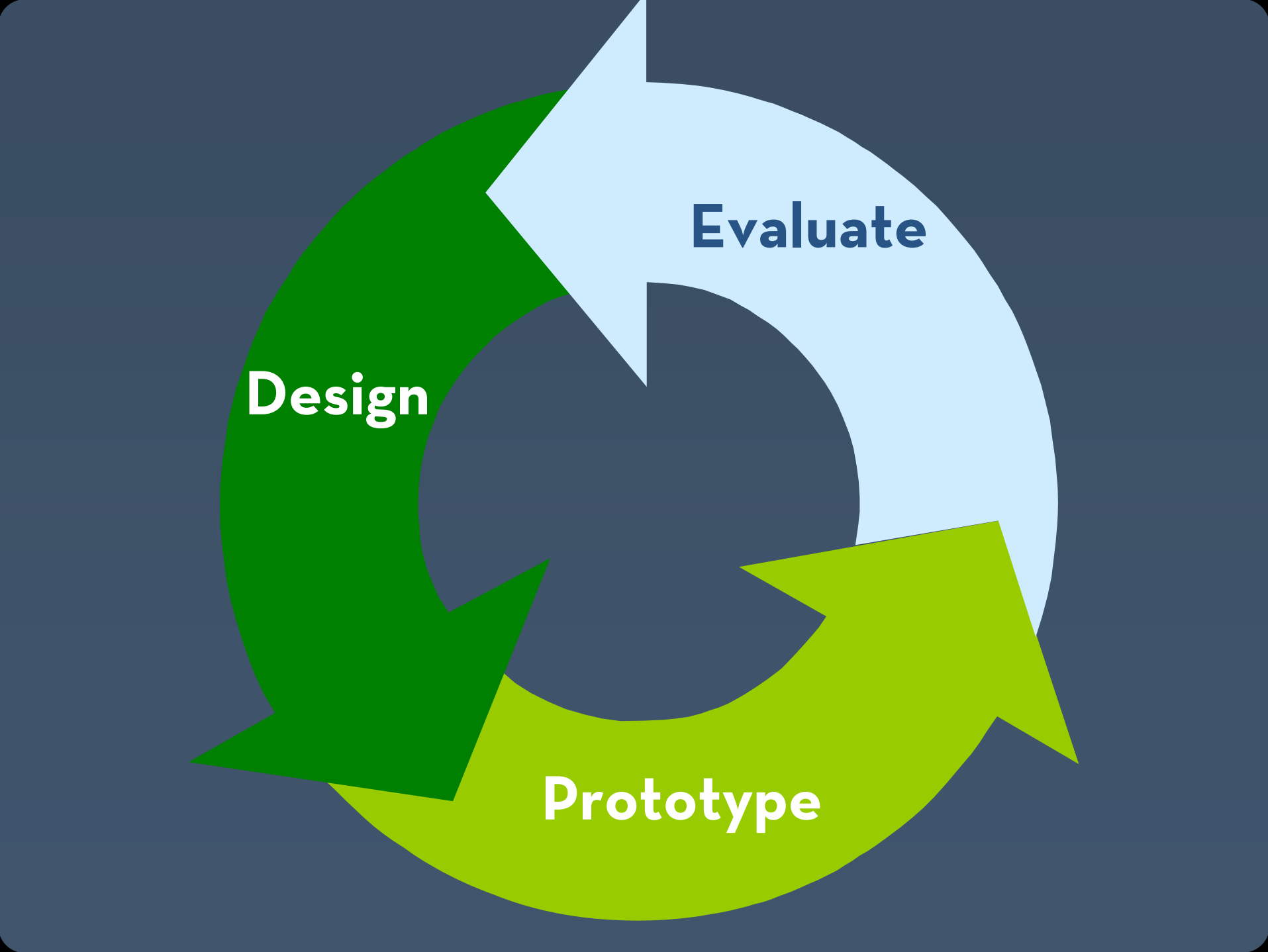
Looks-like

Works-like

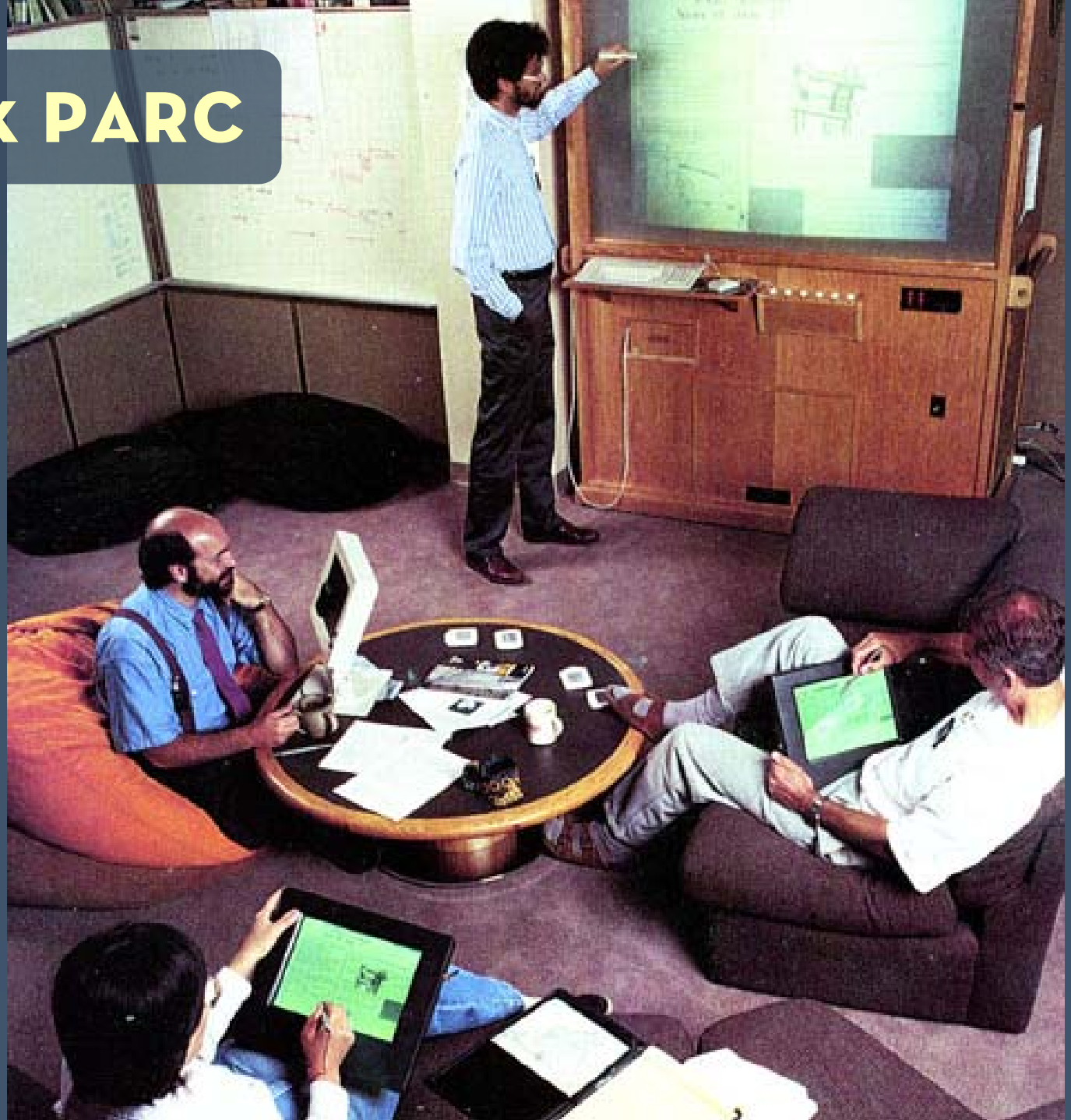
Experience

Prototyping & Design Thinking

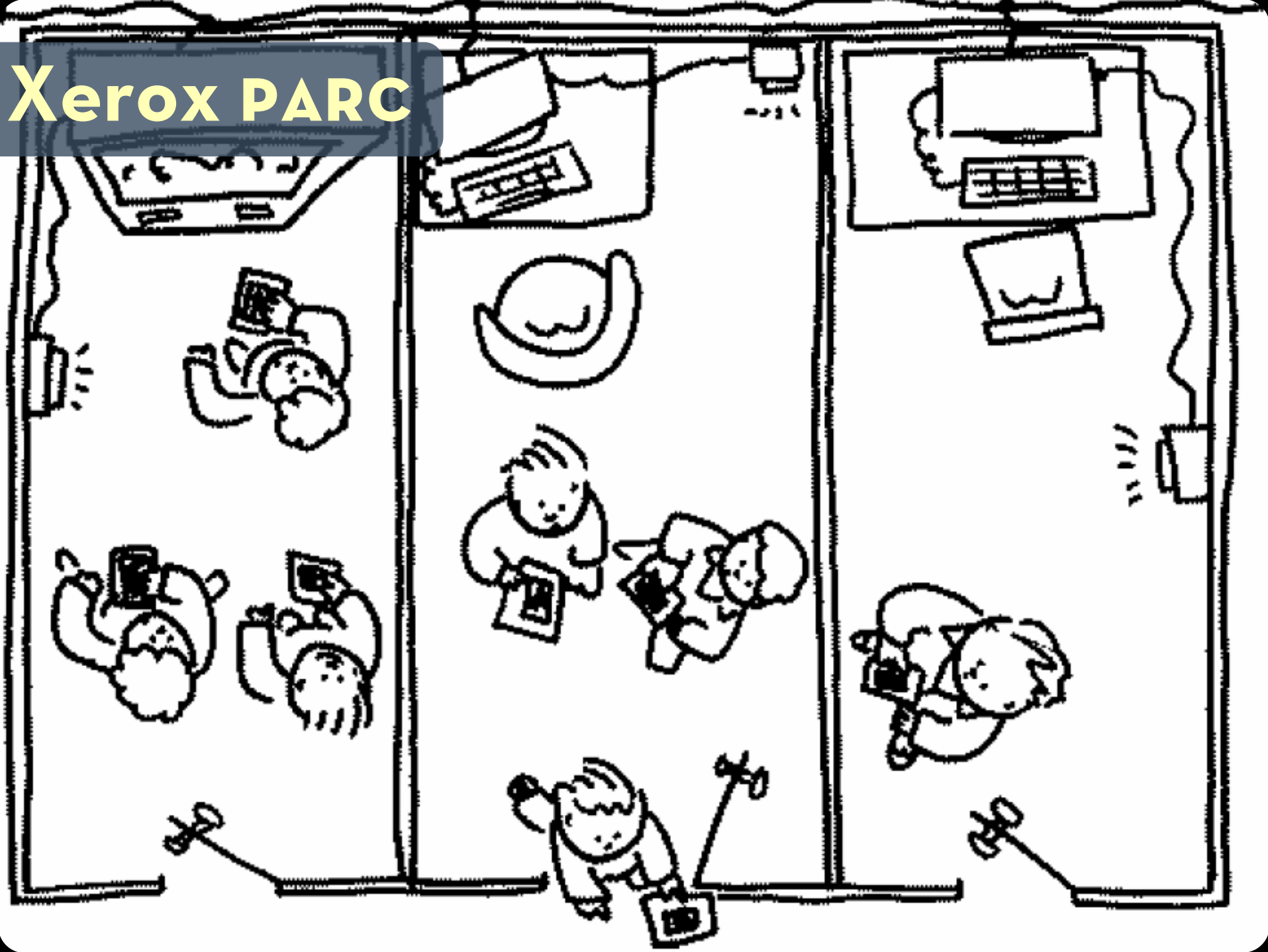
- Working it through, rather than just thinking it through
- “Essential medium for information, interaction, integration, and collaboration”
- “Conversations with materials”


Evaluate
Design
Prototype

Xerox PARC



Xerox PARC



Video: d.school course

"Experiences in design thinking" – day 1

Interview a partner about their wallet

Distill the essence of their wallet experience

Prototype a new wallet

Test it with a user

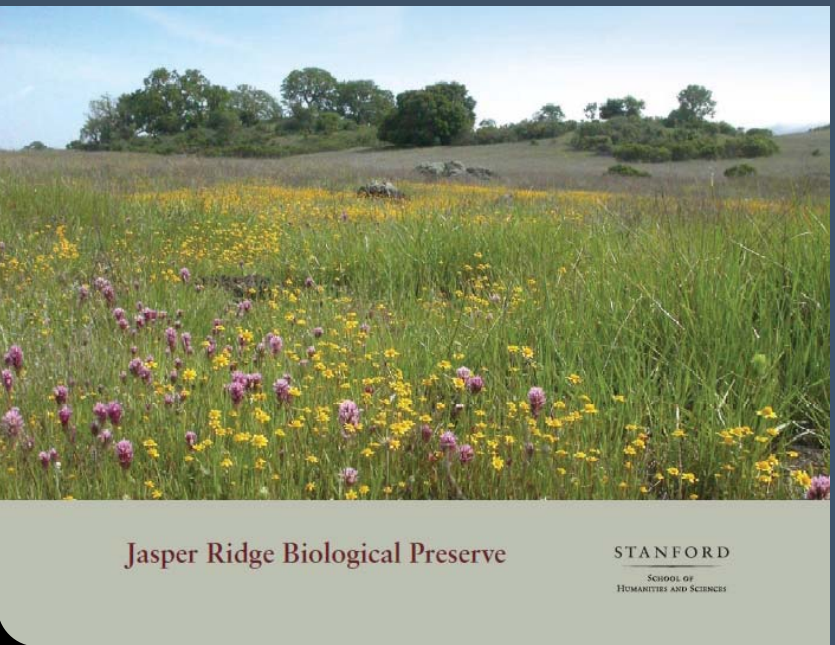
...all in an hour

hci group | infolab

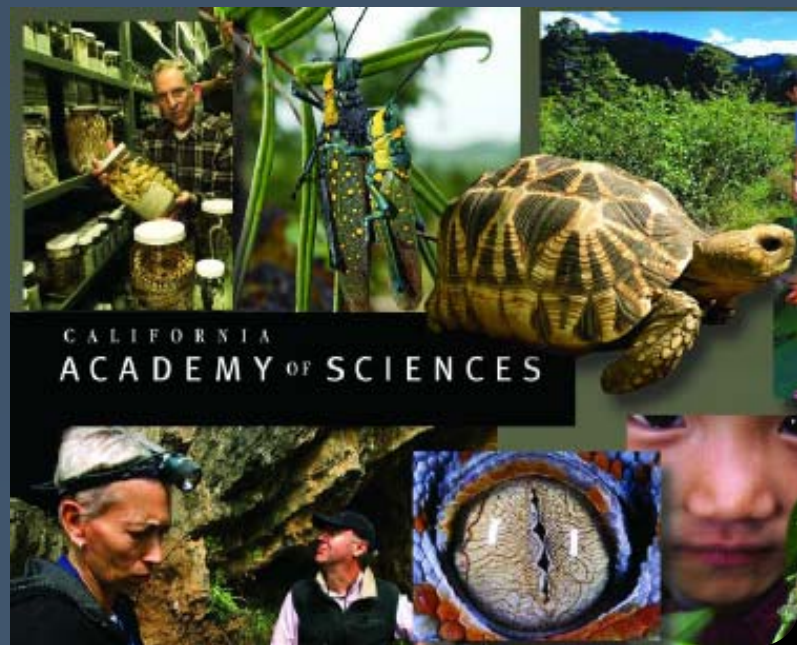
Computer Science @ Stanford

BioACT

Jasper Ridge Biological Preserve



California Academy of Sciences



Mission Statement

Build tools and techniques to help field biologists collect, organize, and share their information.

Outline

Fieldwork
studying field biology researchers

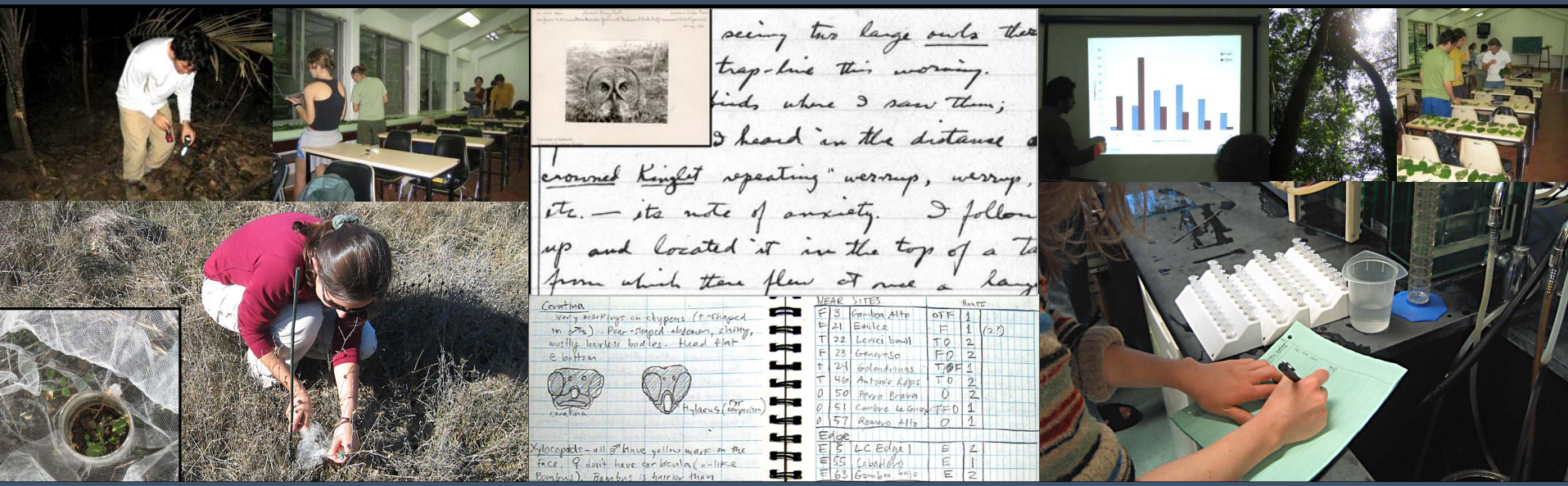
Interaction Techniques
mobile capture and access

Future Work
designing ensemble interactions

Need Finding

What do field biologists do?

Do they work with anybody else?

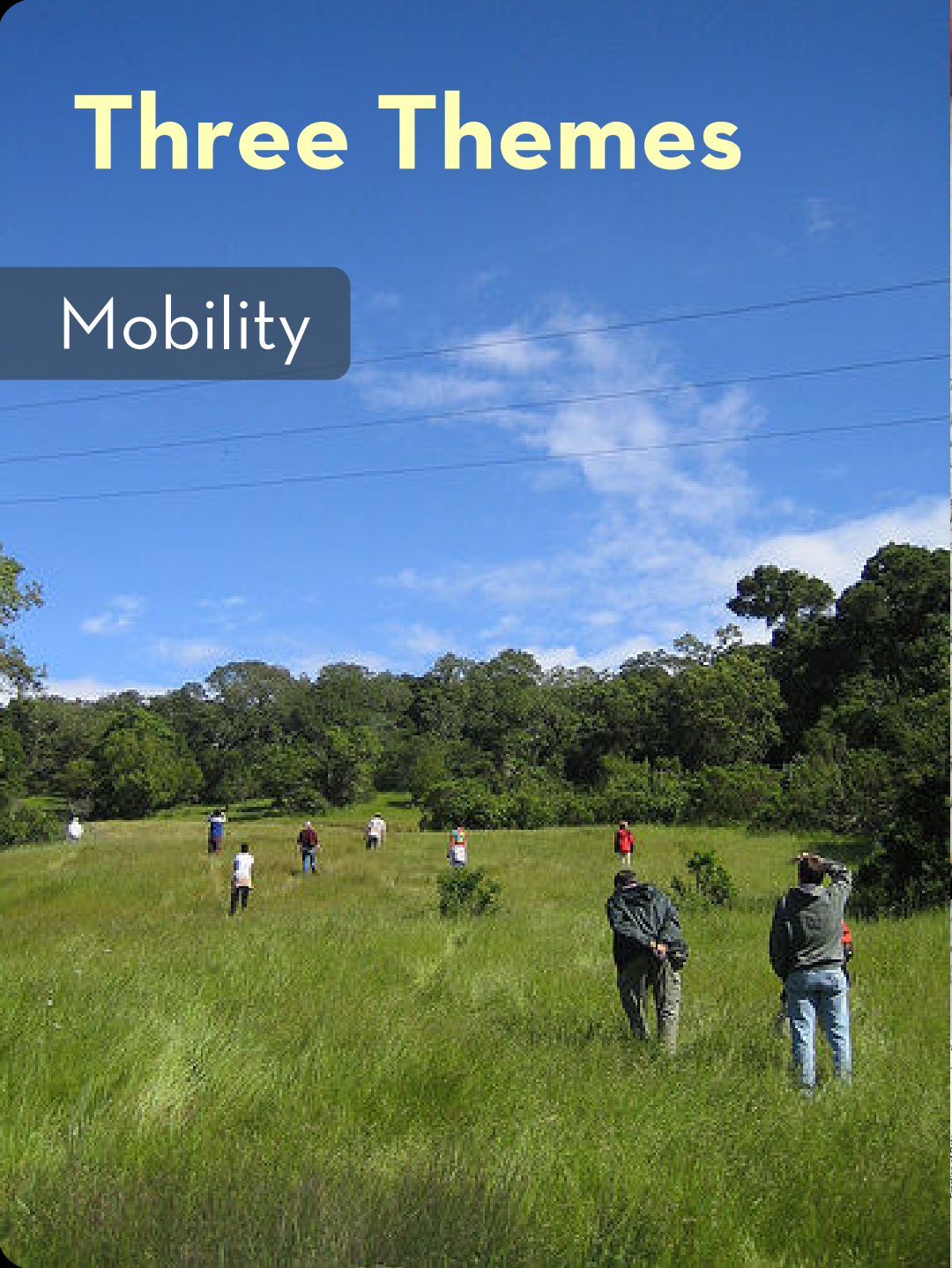


What tools do they use?

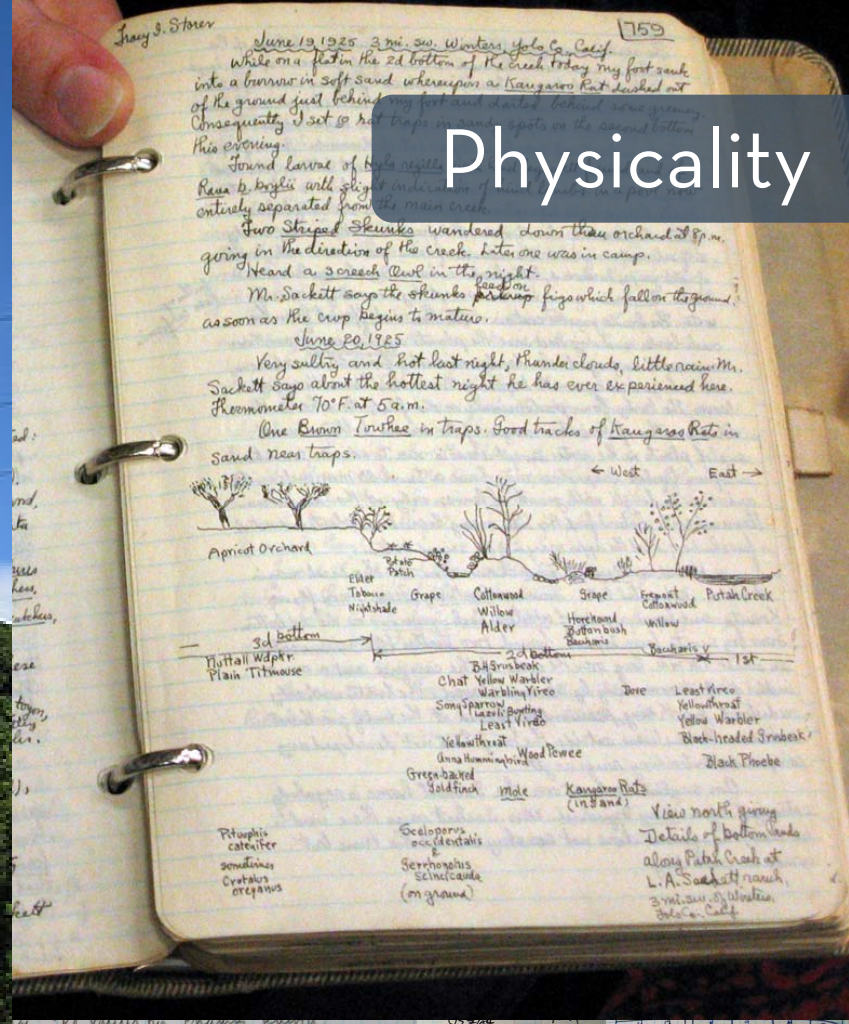
What is their work environment like?

Three Themes

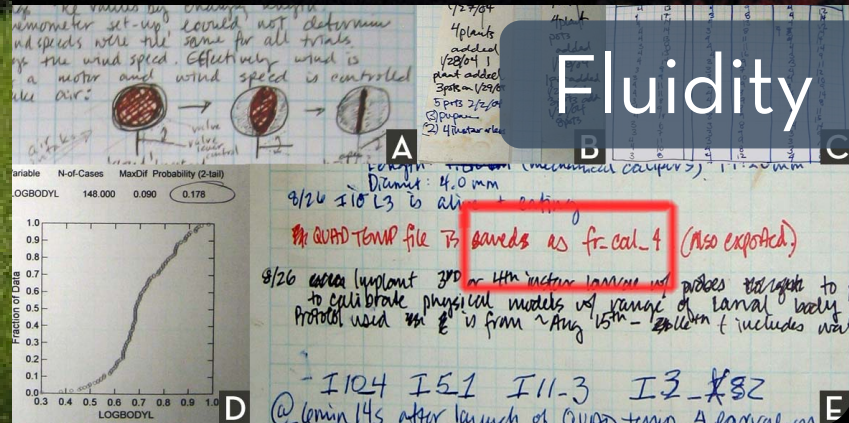
Mobility



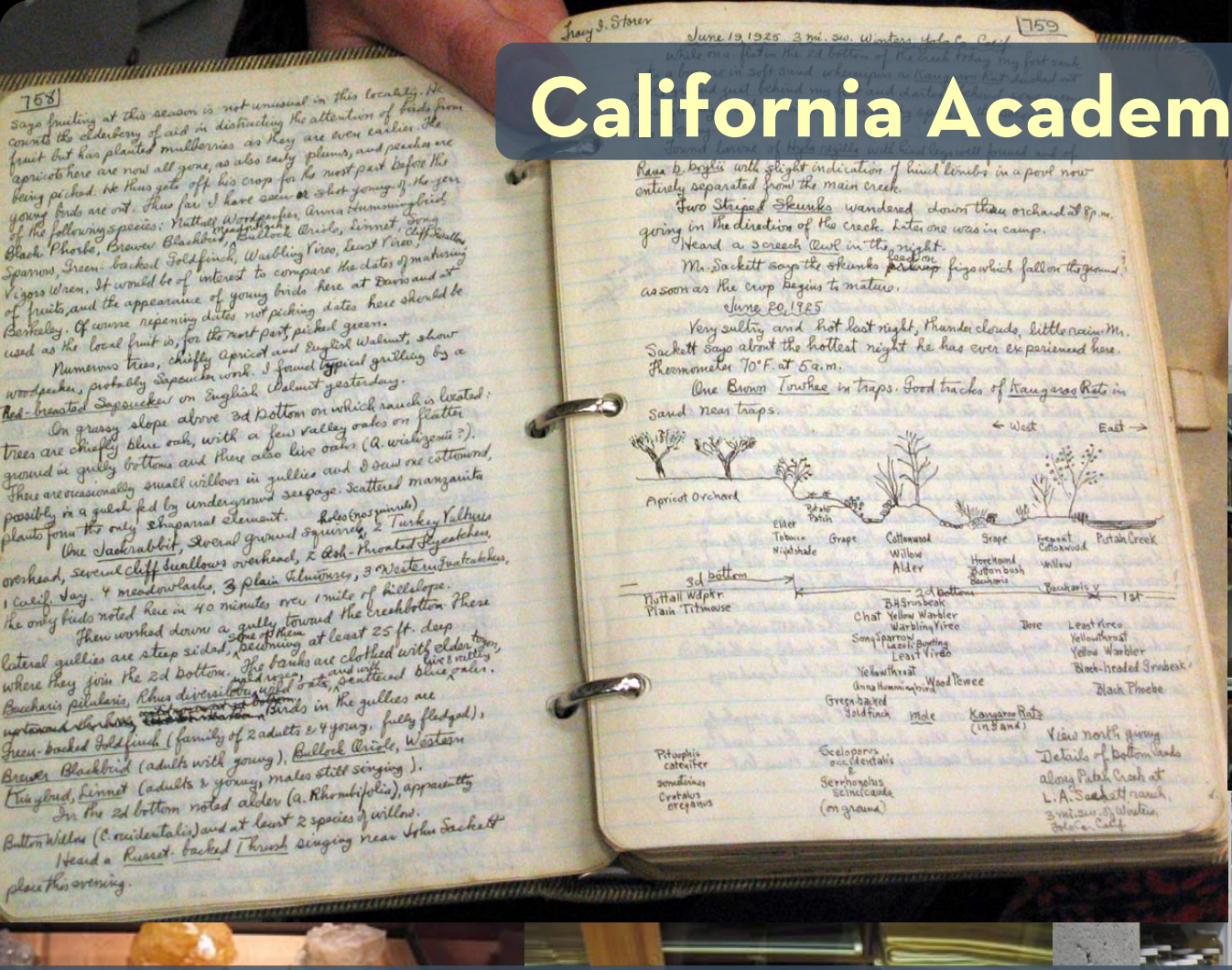
Physicality



Fluidity



California Academy of Sciences



Tracking Samples and Specimens

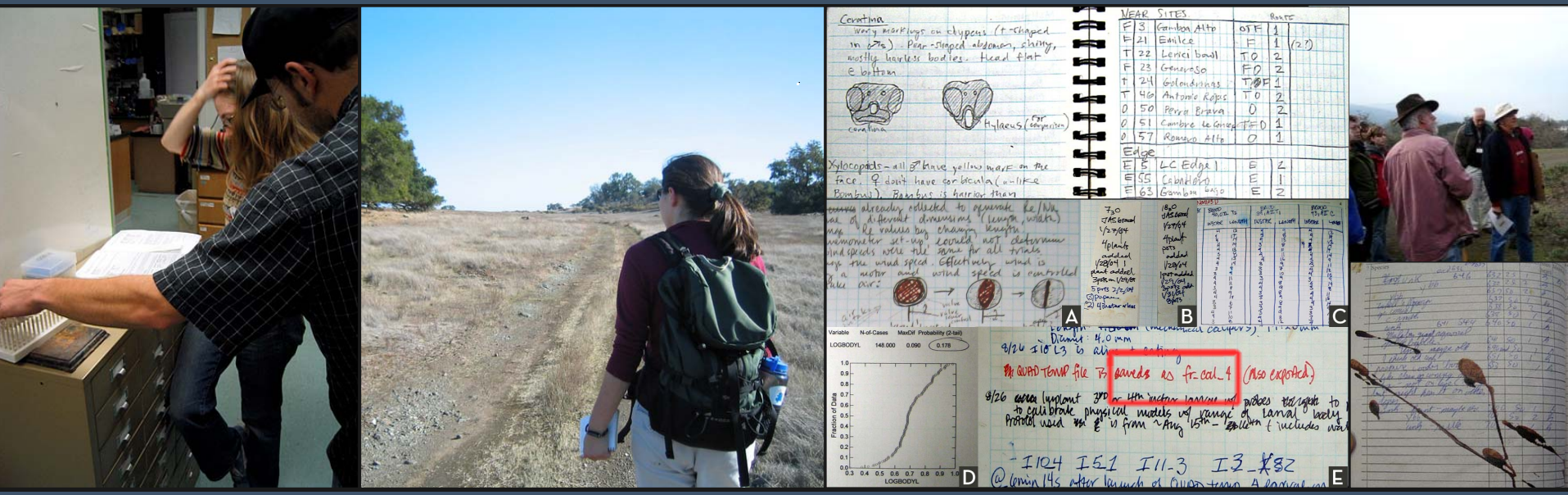
Sharing is Important.... However, notebooks can be locked away forever (good & bad)

Structured Interviews

Interviewed 20 Biologists (Stanford, JRBP, CalAcademy)

In-depth interviews with 10 Stanford Biologists

Analyzed 471 notebook pages from 13 notebooks



Paper Notebook, Data Entry, Capture Heterogeneous Data

Properties of Paper Notebooks

Paper notebooks are a central organizing artifact
Notebooks contain heterogeneous content (tables + text)

Advantages

+ Reliable, Robust, Easy to Browse, Flexible Input, Readable Outdoors, Portable, Infinite Battery Life

Disadvantages

- Static Organization, No Text Search, No Redundancy, Difficult to Share

Combining Advantages

Paper Notebook [Robust, Battery, ...]

Computers [Search, Storage...]

Digitizing Pen Technology

Off-the-shelf digital pens

Benefits

- Backup of Notebook
- Handwriting Recognition
- Easy to Share Notes
- Novel ways to store and retrieve notes
- 10x Cheaper + 10x Longer Battery Life

		PGI	PGM	G6PD
GEL I:	1A	3/4	3/3	2/2
	1B	3/3	3/3	1/1
	1C	4/4	3/4	1/2
	1D	3/4	4/4	2/2
	1E	4/4	3/4	1/2
	1F	4/4	3/3	2/2
	1G	4/4	3/4	2/2
	1H	3/4	3/4	~~2/2~~ 1/2
	11A	3/4	3/3	1/2
	11C	3/4	3/4	2/2
	11D	3/4	3/4	1/2
	27A	3/3	3/3	1/2

PROCEDURAL NOTES: 2 GELS

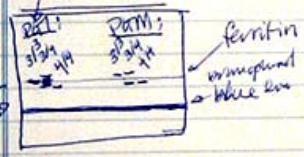
correction - re-read gel

STAINING NOTES from W.B. WHITT:
PGI - 3 on ferritin
PGM - acts as 2 monomer
G6PD - tetramer

Heterozygote banding 1:4:6:4:1 only visible part.

STAINING NOTES cont:

PGI/PGM:



JAS 11/12/04 CER RMBL 2004 STANFORD

Subject / Keywords
RMBL_2004_CER_NOV_12-04

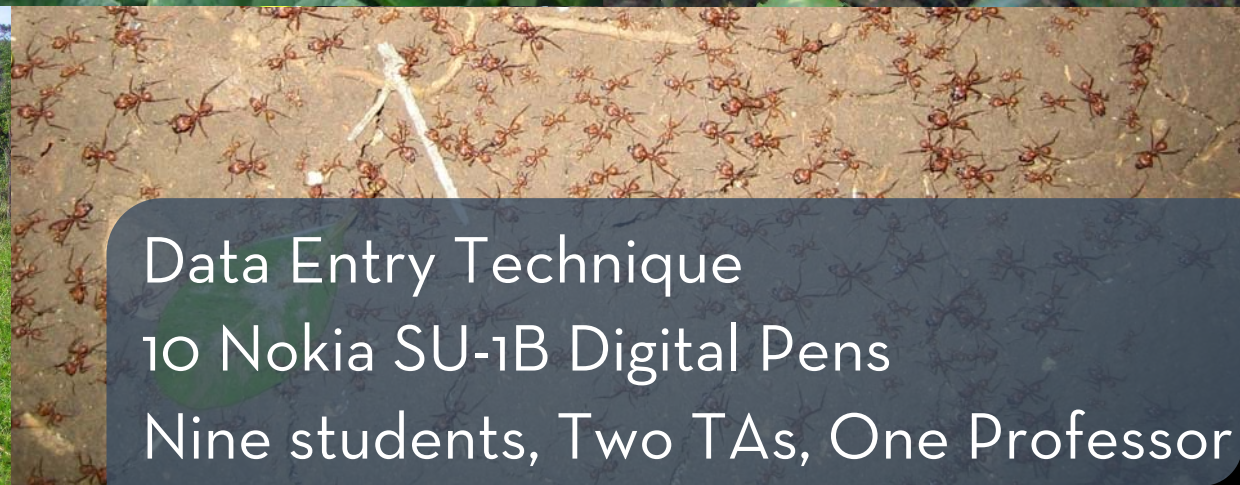
To

E-mail ☐ Note ☑ Other ☐

Done

CAMBRIDGE Limited

Los Tuxtlas Tropical Rainforest



Data Entry Technique
10 Nokia SU-1B Digital Pens
Nine students, Two TAs, One Professor

Results

Field Resources Limited

Time (Daylight hours)

Labor (Always need more hands, assistants)

Transportation (Hike for long distances)

More time and resources back at the lab

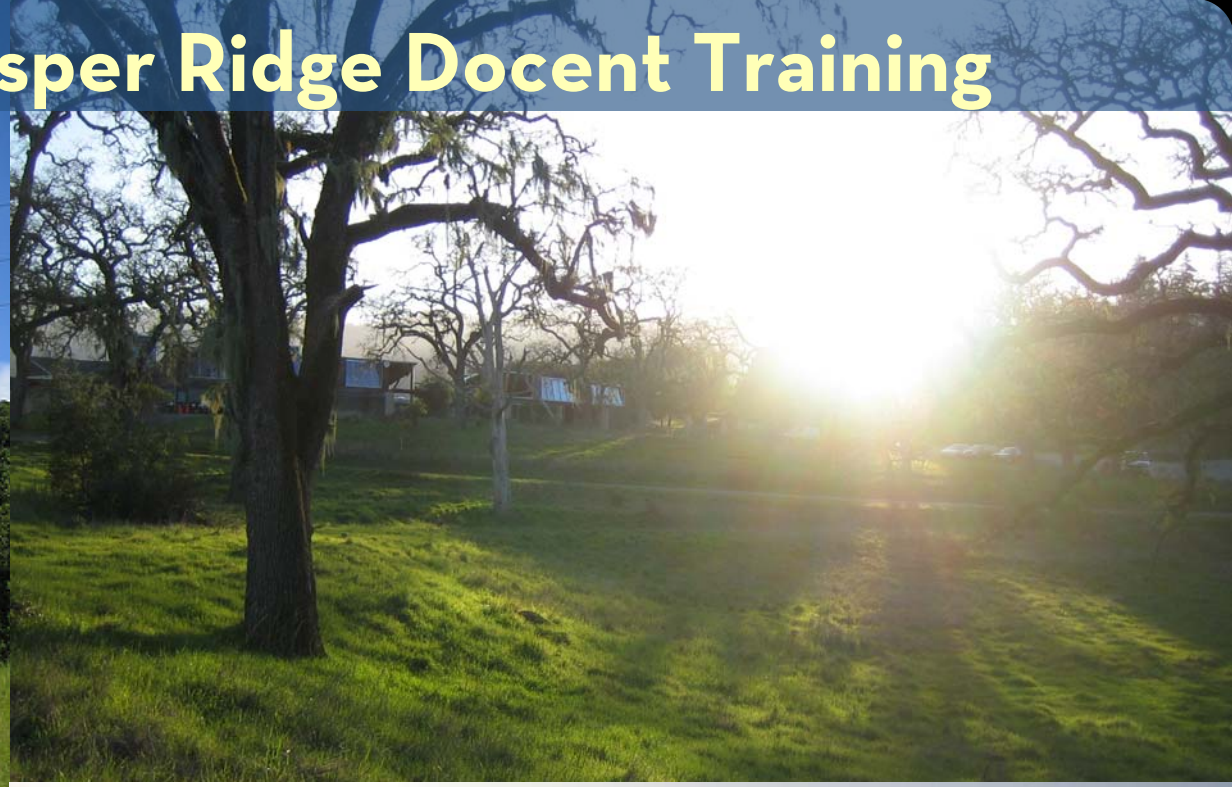
Digital Pens suitable for both field and lab

Results

Collaboration
Data Capture & Access (Photos, Notes)
Experimental Methods

Highly Mobile

Biology 96A/B Jasper Ridge Docent Training



Collaboration (Researchers, Docents...)
Biologists are Mobile
Environmental Sensing

Digital Camera Traps

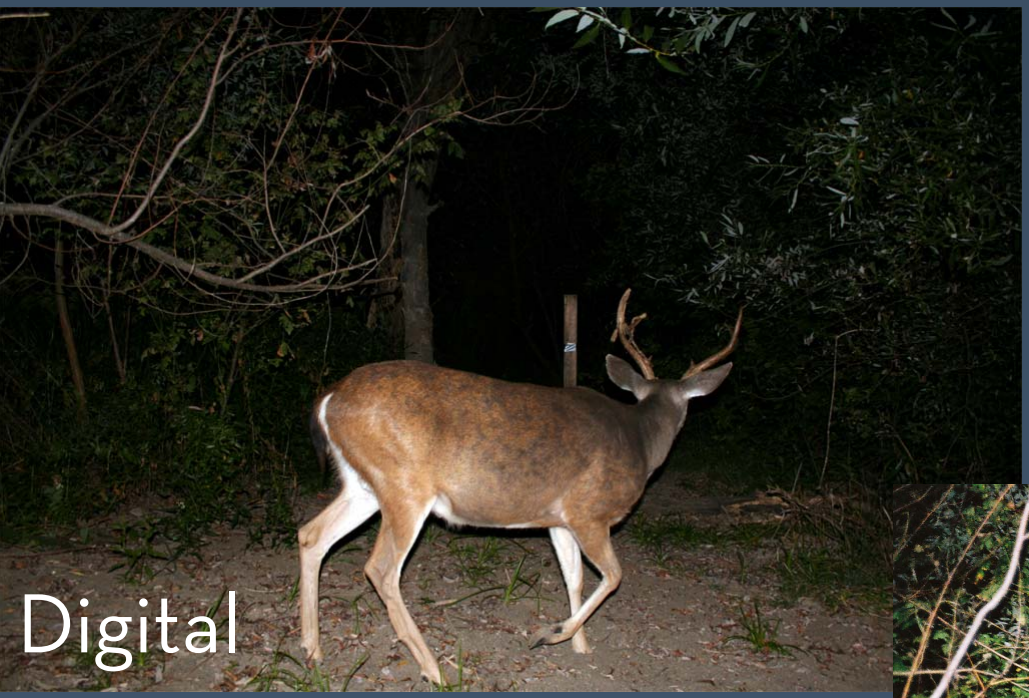
Companion Project to
Professor Rodolfo Dirzo's
Camera Trapping Project

Led by Myself,
Gary Nielsen, & Bill Gomez

Value

- Gain Trust
- Gain Research Experience
- Opportunities to Deploy our Tools

Digital Camera Traps



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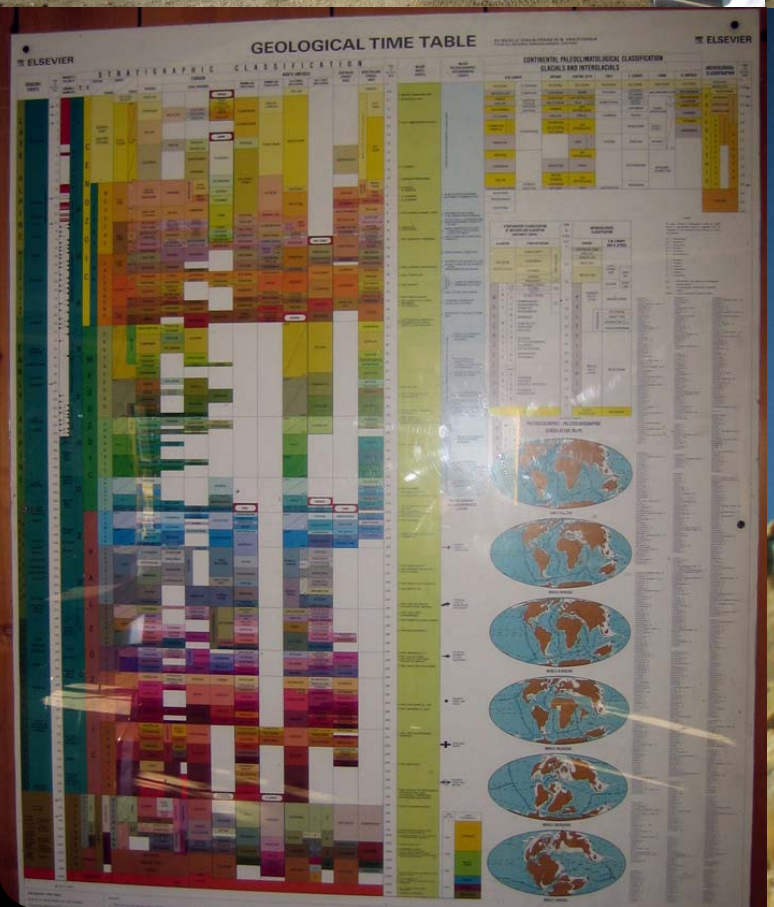
White Mountain Research Station



Alternative Paper Formats (Posters, Maps...)

Remote Monitoring

Network Connectivity @ 14246 ft

Time with Biologists

Interviewing, Studying, and Working With Biologists (329 hours)

Contextual Inquiry and Interviews	41 hours, 20 different Biologists
Bio96A/B JRBP Docent Training	120 hours
Bio175 Los Tuxtlas Rainforest	120 hours
Digital Camera Trapping	8 hours
White Mountain Research Station	40 hours

Discussing Ideas and Demonstrating Prototypes (10 hours)

Studying our Technology (35 hours)

- User Study with 14 Biologists x 2.5 hrs

Total of **374** hours over 12 months (~7 hrs per week)

- Continuing to talk to and work with biologists

Outline

Fieldwork
studying field biology researchers

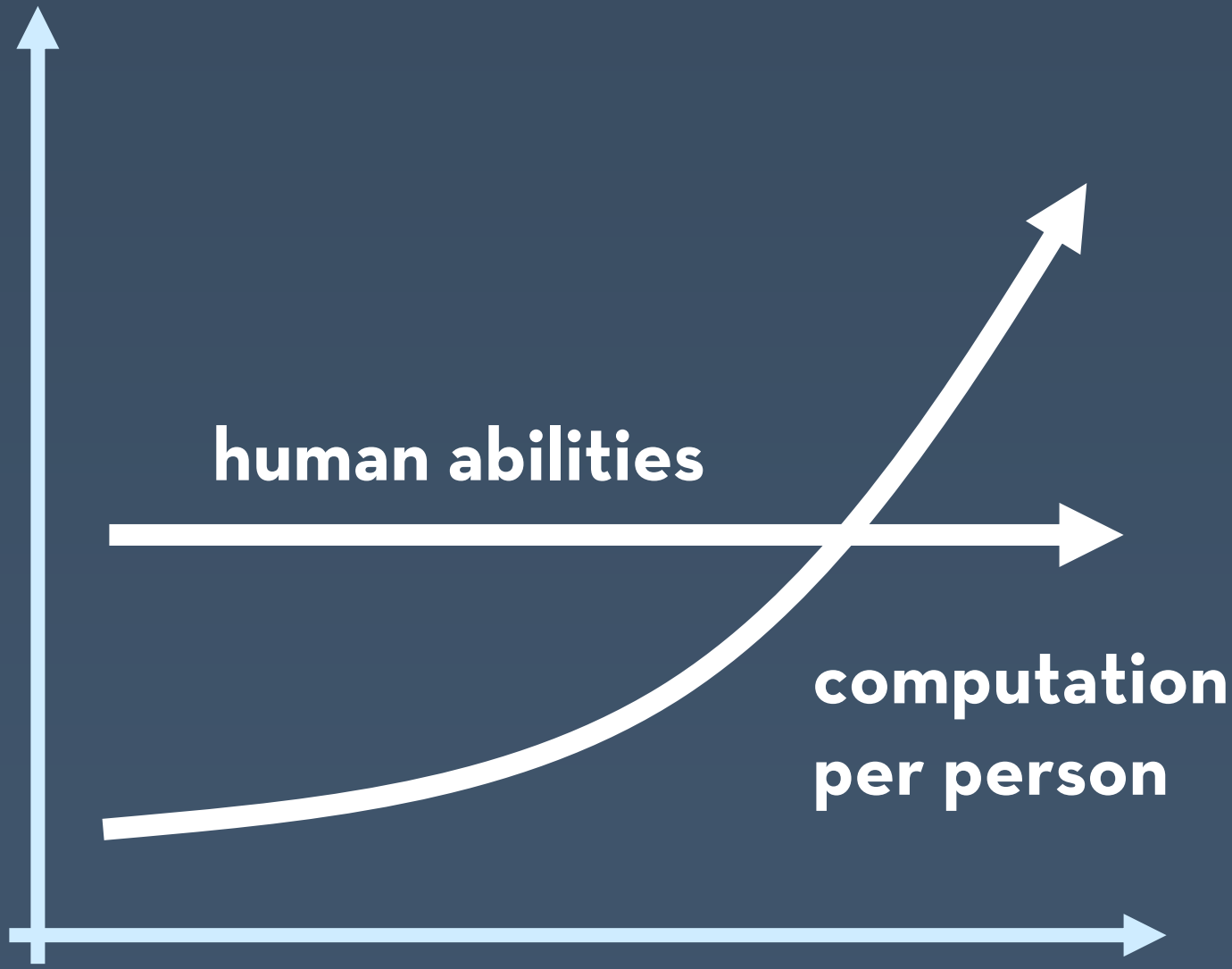
Interaction Techniques
mobile capture and access

Future Work
designing ensemble interactions

Motivation

Capture is easy, but...

Access is not


human abilities
computation
per person

notes @ 4:43pm

photo @ 4:44pm

1 Automatic Association

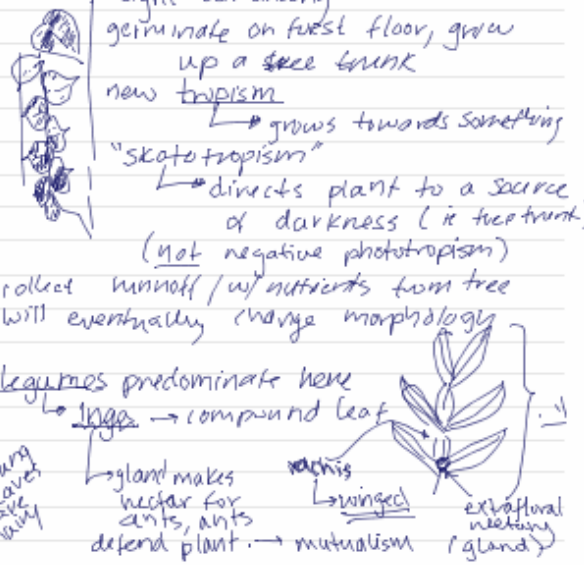
Notes + Photos associated by Time

March 20, 2005

March 28, 2005

Piper → light demanding (used in cooking)
→ aurilimbum "ye-boganta"
→ more dramatic inflorescences

araceae monstera
light demanding
germinate on forest floor, grow up a tree trunk
new tropism
→ grows towards something
"skototropism"
→ directs plant to a source of darkness (ie tree trunk)
(not negative phototropism)
collect runnoff / w/ nutrients from tree
will eventually change morphology



legumes predominate here
→ Inga → compound leaf
→ gland makes nectar for ants, ants defend plant → mutualism
young leaves are tasty
rachis → winged
extrafloral nectary (gland)

Sun Mar 20 14:02:22 PST 2005 ...
Mon Mar 21 15:07:54 PST 2005

4

epiphylls → things that grow on leaves
many Inga species
* termite mound
cordia
→ high quality wood

→ two layers

"leaf mining" → microlepedoptera
type of herbivory
larvae eat around inside leaf.
"epiphyllism" leaf. → protected inside leaf.

Burseraceae Bursera
→ living fence tree
dioecious
bark peels off (red)
→ "exfoliating bark"
green stem (trunk) → photosynthesizes (lenticles)

Costus → interesting in flower
→ ginger, lots of herbivory

Sun Mar 20 14:15:20 PST 2005 ...
Sun Mar 20 14:31:42 PST 2005

5

1 Automatic Association

Notes + Photos associated by Time

Cathy Thompson | Los Tuxtlas | Spreadsheet | 4 of 53 | 2 pages

Cathy Thompson - Los Tuxtlas - ButterflyNet
3/20/05 4/19/05

pipers, "designed" to be dispersed by bats.
flower on outside, tasty stock inside
inflorescence (infruitescence) → darker
→ light demanding, dispersal is important
windpollinated
argument against bats → birds hang out in the piper

* heard howler ~~[illegible]~~ monkeys
2 species here
- howler monkey - Aloatta paliata
- Spider monkey - Ateles (haven't seen them here in 20 years)
→ hunted were for meat

*Araceae
→ Vines, grow on other trees
herbacious (liana is also climbing, 2° growth)
→ Not a vine

anthurium

leaf morphology difference

one exception → dieffiembachia
- not a climbing vine

- Bonus pollinate

March 20
Mar 20 1:46 pm - 2:00 pm

Import photos

Cathy Thompson - Los Tuxtlas - ButterflyNet
3/20/05 4/19/05

Piper → light demanding (used in cooking)
↳ auritum "yerbasanta"
→ more dramatic inforescences

aracene monstera
light demanding

germinate on forest floor, grow up a tree trunk
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↳ Inga → compound leaf
young leaves are hairy
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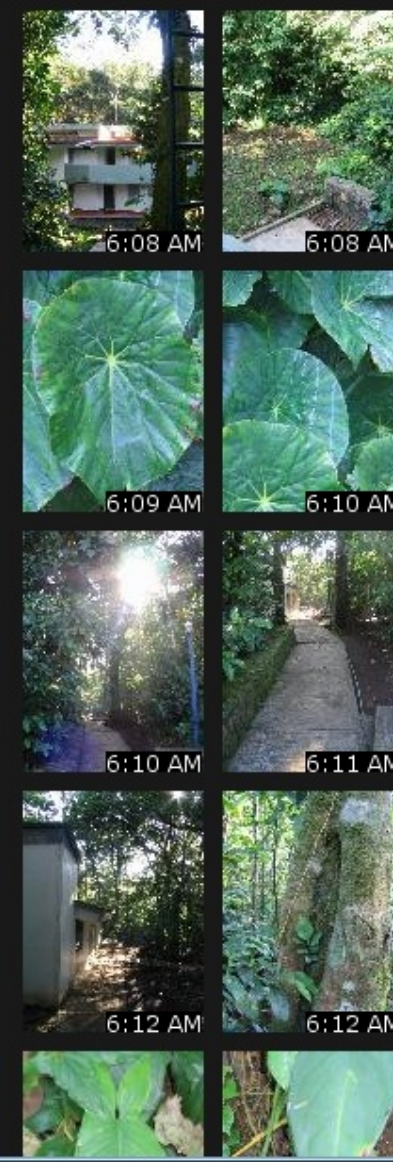
rachis
↳ winged
extrafloral nectary (gland)

March 20
Mar 20 2:02 pm - Mar 21 3:07 pm



Import photos

Cathy Thompson - Los Tuxtlas - ButterflyNet

3/20/05

4/19/05

March 20 4

March 20 5

March 20 6

March 20 7

March 20 8

March 20 9

March 20 10

March 21 11

9:28 AM

9:28 AM

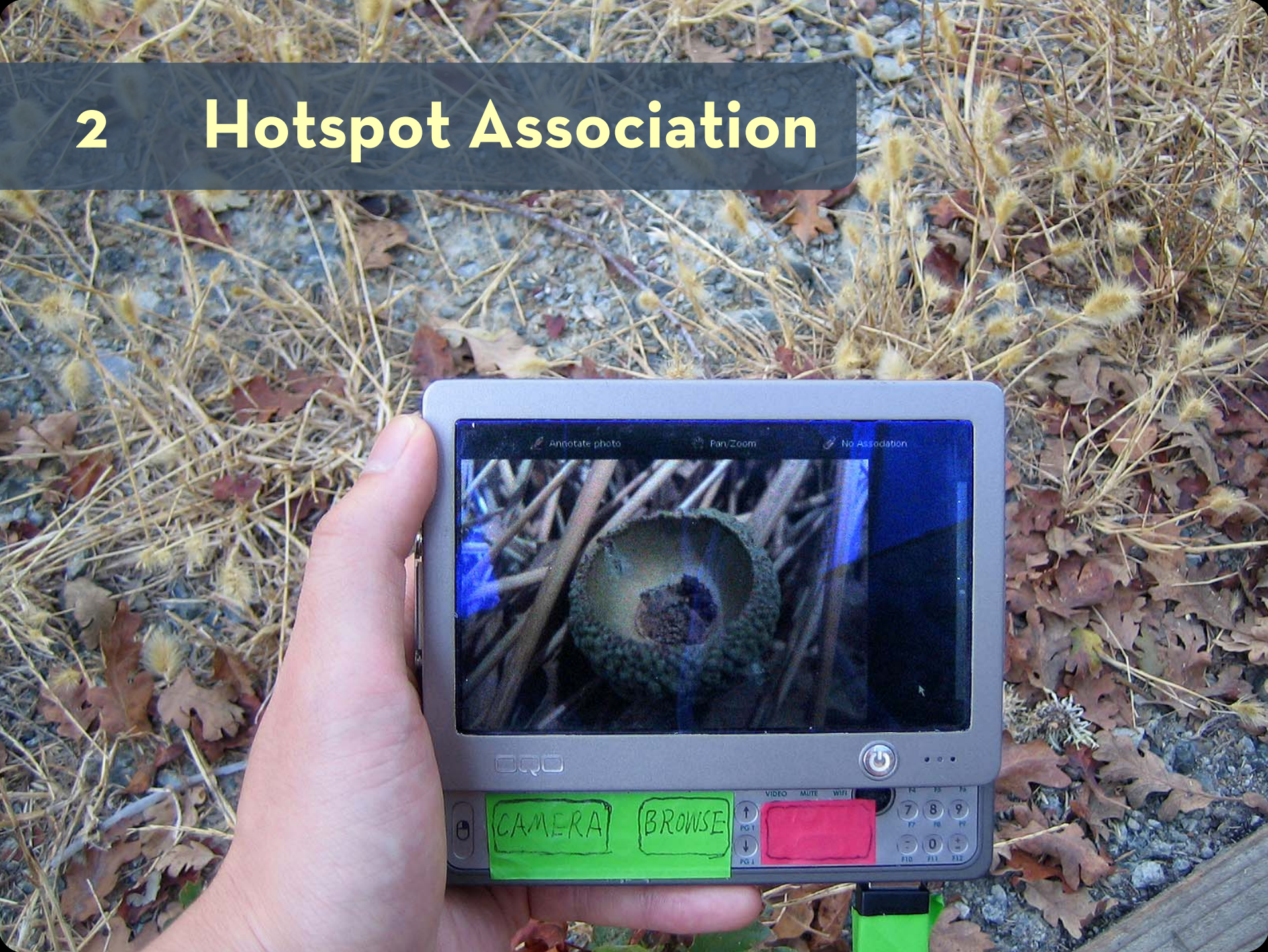
9:29 AM

9:29 AM

Import photos

Cathy Thompson | Los Tuxtlas | Refresh | 4 of 53 | 4 pages

2 Hotspot Association



July 22 2005
at Searsville lake I found an
intresting specimen:
Transect 2
21.2m
mark.
med. fern
846, 48

Back at the Lab...

Ron Yeh - UserStudy - ButterflyNet

September 02, 2005 — September 21, 2005

July 22 2005
at Searsville lake I found an interesting specimen:

Transect 2
21.2 m
mark.

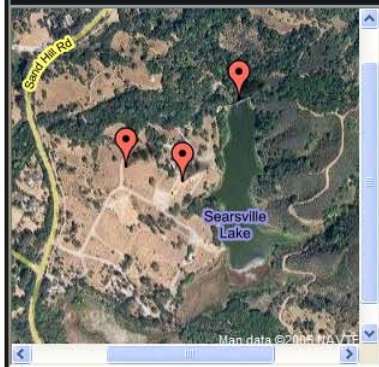
acorn cap.

This cap was clearly carried from its original location.

Wed Sep 21 17:35:03 PDT 2005 ...
Wed Sep 21 17:58:54 PDT 2005

26

27



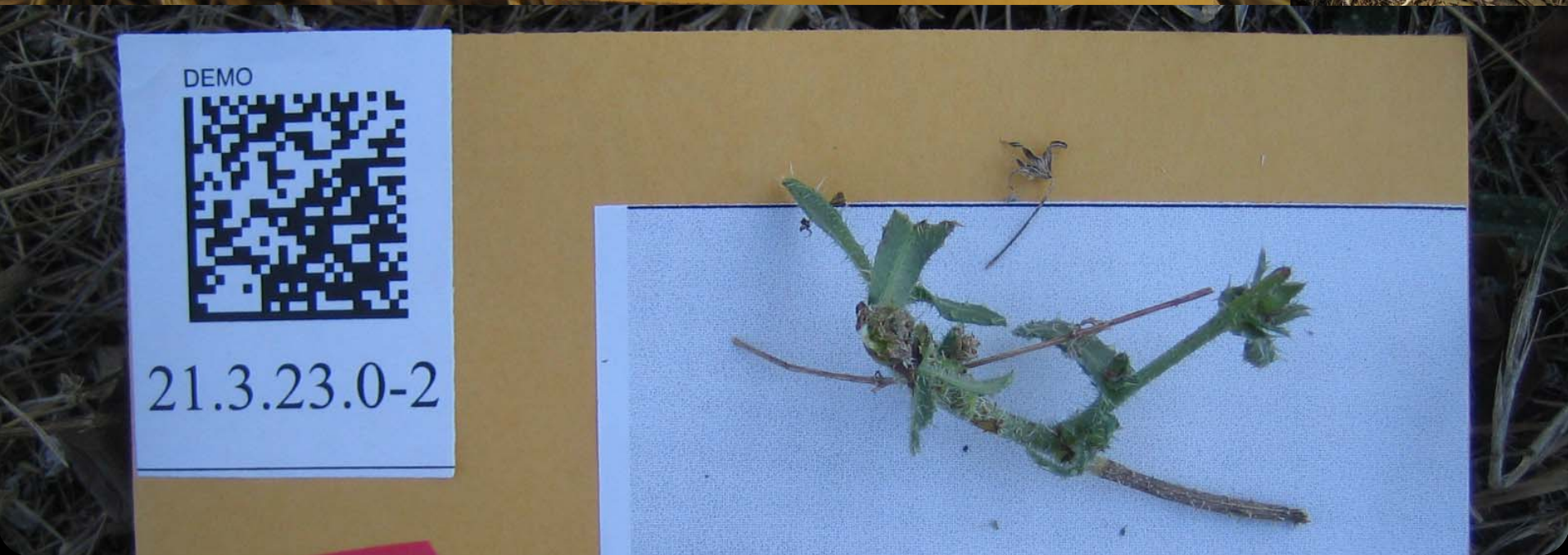
Transect 2B

Temperature (degrees C)

Time

Ron Yeh | UserStudy | Spreadsheet | 26 of 61 | 2 pages

3 Visual Specimen Tags



Cathy Thompson - Los Tuxtlas - ButterflyNet

March 20, 2005 — March 28, 2005

piper → light demanding (used in rocking)
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→ more dramatic inflorescences

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costus → interesting in flower
→ ginger, lots of herbivory

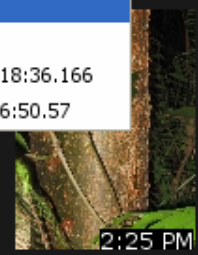
Sun Mar 20 14:15:20 PST 2005 ...
Sun Mar 20 14:31:42 PST 2005
5

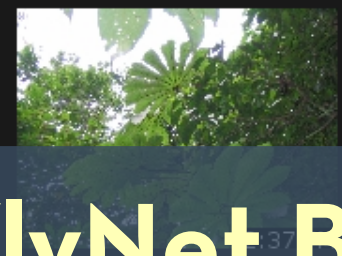
Copy to clipboard
Send to spreadsheet
Start time: 2005-03-20 14:18:36.166
End time: 2005-03-20 14:26:50.57

2:05 PM

2:06 PM

2:07 PM

2:22 PM

2:25 PM

2:31 PM


costus → 2 types here (one is eaten much more than the other)
what is the difference
velvety
glaborous

moraceae (figs)
white latex, (quickly oozing, dense)
collecting venation pattern
very pointy tips ("acumen") "drip tips"
"actinodromous venation"
latex → waste product, defence

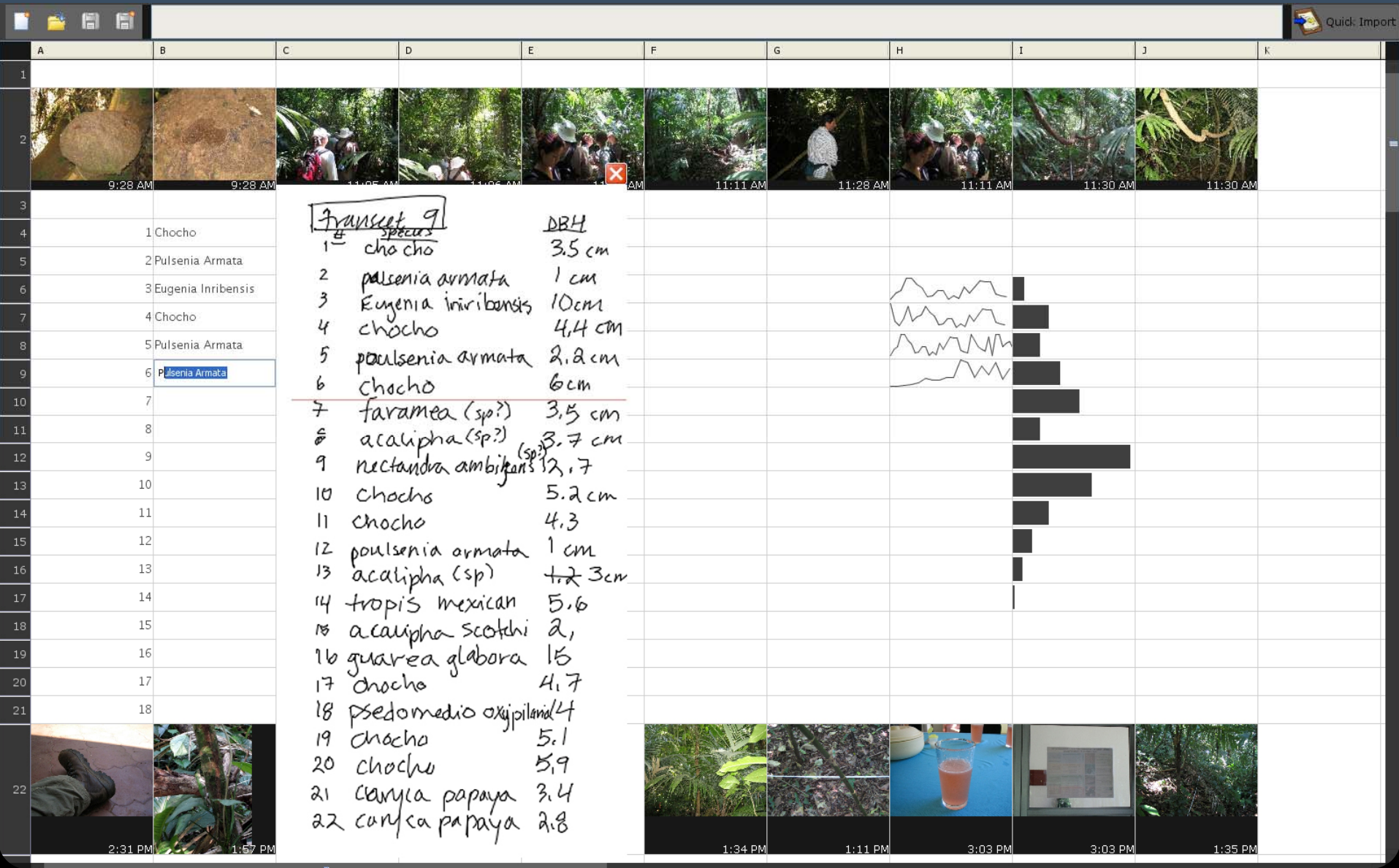
piper → monoecious, sassafrass smelling
aurantium → light greedy piper species

legume
acacia
→ mutualism
ant
ant
defend plant (Dan Janzen)
→ how to regrow a
stipules → hollow
Ants live here.
"Beltian bodies" on tips of new buds (lipids)

ButterflyNet Browser

Cathy Thompson | Los Tuxtlas | Spreadsheet | 4 of 53 | 2 pages

Multimedia Spreadsheet



Physical + Digital Ensemble Interactions

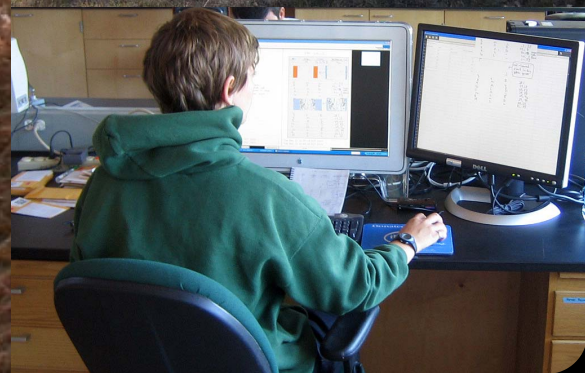
Hotspot Association

Navigate by Pen

Send to Spreadsheet by Pen

Paper as a Backup for Digital (Browsing)

User Studies



14 Participants (Biologists)

Participant Feedback:

- \+ Automatic Capture and Correlation
- o Handwriting Recognition with Data Sheets
- o GPS and Sensor Data Integration

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ABSTRACT

Through a study of field biology practices, we observed that biology fieldwork generates a wealth of heterogeneous information, requiring substantial labor to coordinate and distill. To manage this data, *biologists leverage a diverse set of tools, organizing their effort in paper notebooks.* These observations motivated ButterflyNet, a mobile capture and access system that integrates paper notes with digital photographs captured during field research. Through ButterflyNet, the activity of leafing through a notebook expands to browsing all associated digital photos. ButterflyNet also facilitates the transfer of captured content to spreadsheets, enabling biologists to share their work. A first-use study with 14 biologists found this system to offer rich data capture and transformation, in a manner felicitous with current practice.

Author Keywords

Mobile capture and access, augmented paper notebook.

ACM Classification Keywords

H.5.1: Multimedia Information Systems — *artificial, augmented, and virtual realities.* H.5.2: User Interfaces— *input devices and strategies; interaction styles; prototyping.*

INTRODUCTION

Every day, we witness mobile professionals at work—on the subway, at the park, in cafés. On mobile phones, they chat with business partners and write text messages. On their laptop computers, they surf the Web and post blog entries. Yet, despite the availability of these tools, many professionals rely on paper notebooks. To understand why this is, consider the advantages of each medium. Computers afford interactive computation, electronic communication,

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Figure 1. A) Field biologists choose paper notebooks because they are portable, readable outdoors, robust to harsh field conditions, and have infinite "battery life." B) As seen on this office desk, paper notebooks support flexible input and output. C) However, like Tracy Kidder's mythical CAD software, many field biologists dream of a mobile, digital tool for those who might benefit from field notebooks, and digital information management. Paper notebooks, on the other hand, are cheap, turn on instantly, have infinite battery life, and provide a fluid and flexible surface for jotting down ideas on the go. They are also amazingly robust. As a result, paper notebooks support many mobile practices better than computing devices do.

Field biologists struggle daily with this tradeoff. On the one hand, their practice depends on paper notebooks as the central organizing tool, considering its shortcomings necessary to gain the reliability and flexibility of paper (see Figure 1). On the other hand, field biologists depend on computers to analyze data, and must transform their work to do so. This tension suggests a wholesale replacement of paper in current practices. However, a wholesale replacement of paper can be problematic, as evidenced by Sellen and Harper's work [35]. Instead, we argue that it is better to design technologies that complement paper tools: the bits in our computers should be aware of the atoms of our world (see *e.g.* [17, 14, 24]). *Next generation tools should support the capture of heterogeneous data, aid the transformation process, and yet preserve the best aspects of current paper-centric practices.*

Outline

Fieldwork

studying field biology researchers

Interaction Techniques

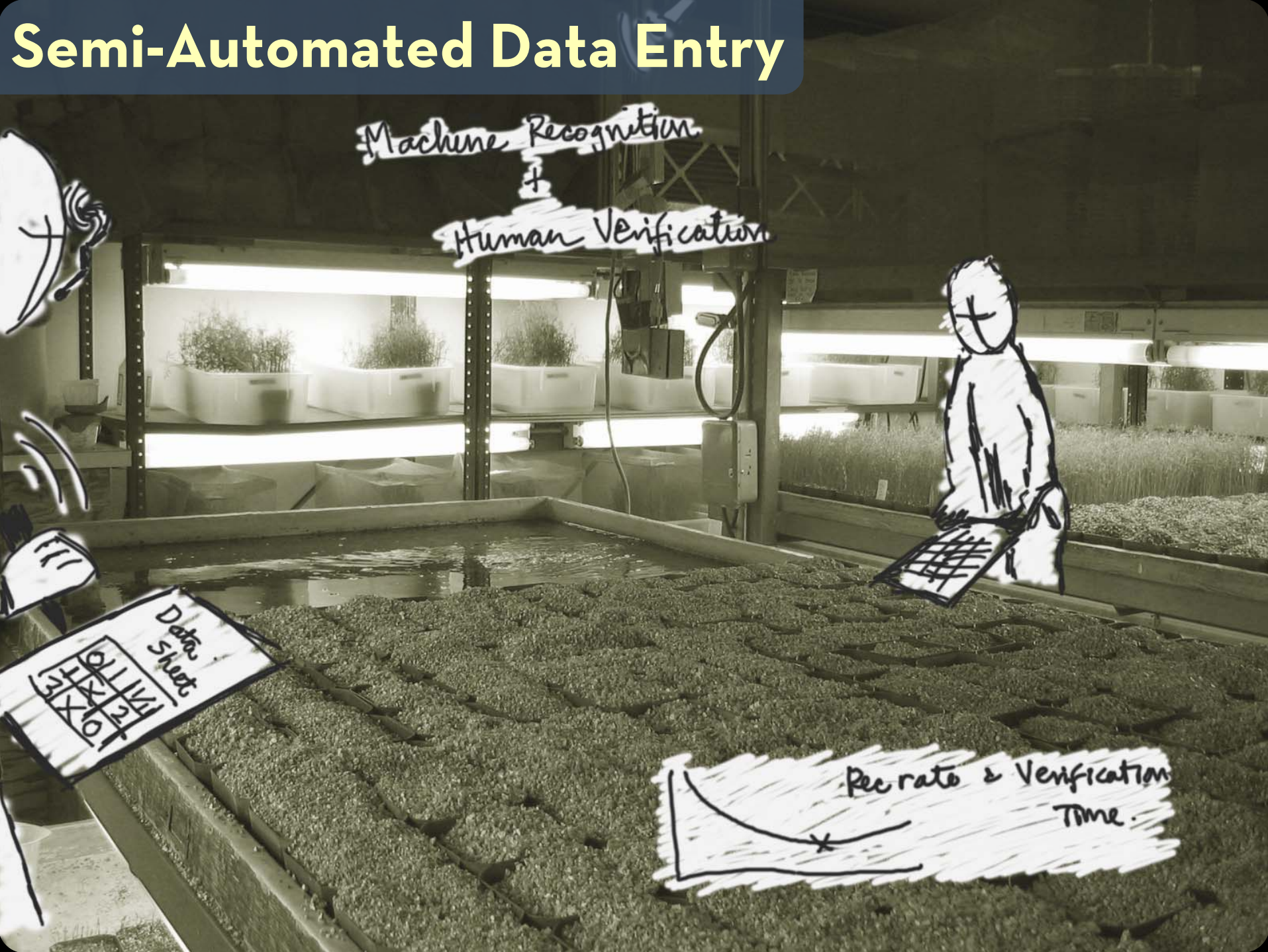
mobile capture and access

Future Work

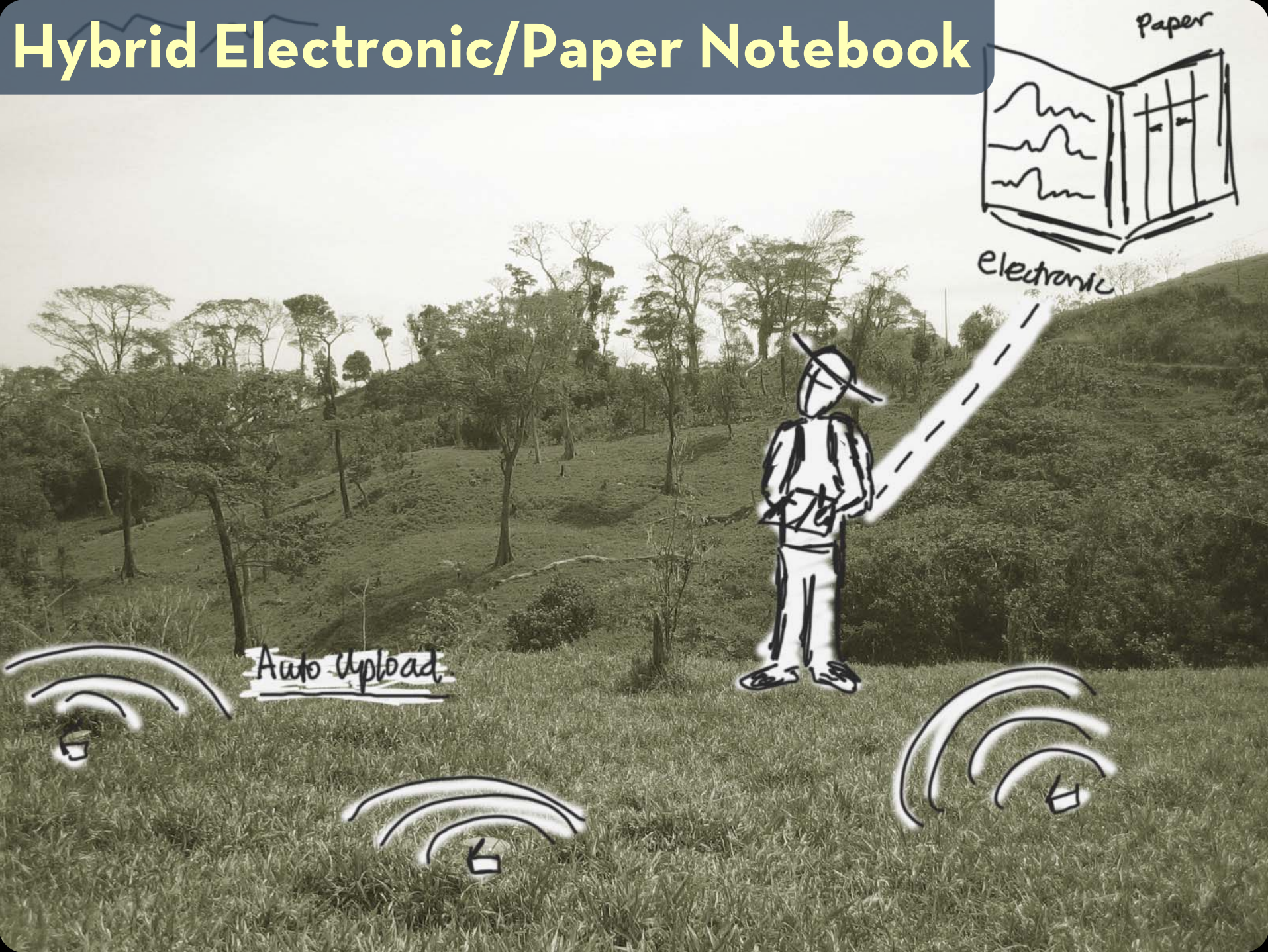
designing ensemble interactions

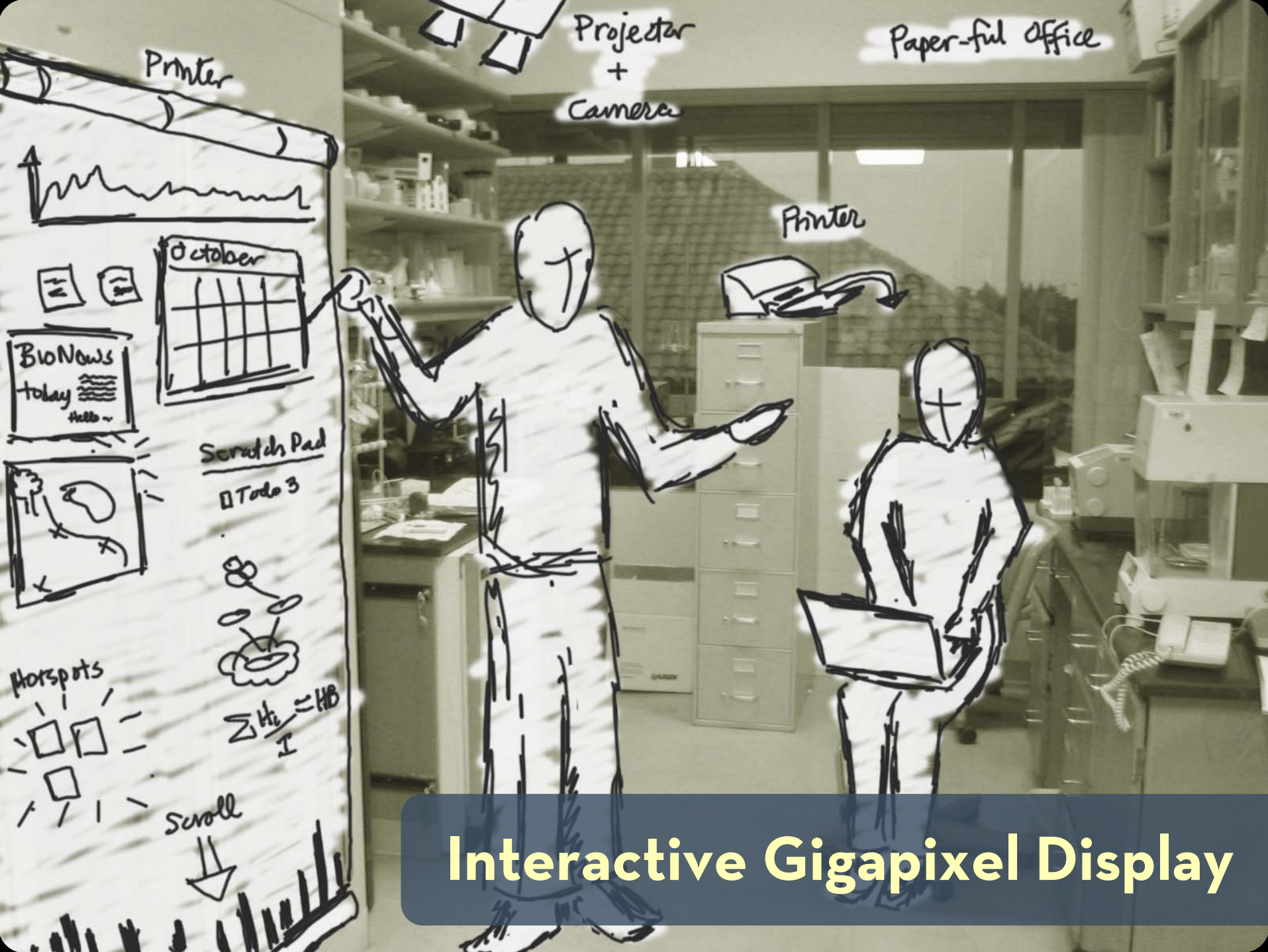
Supporting Design Education

Semi-Automated Data Entry



Hybrid Electronic/Paper Notebook




Printer
Projector
+
Camera
Paper-ful Office
Printer
October
BioNews
today
hello ~
Scratch Pad
Todo 3
Hotspots
Scroll
Interactive Gigapixel Display

Interactive Gigapixel Display

Map-Based Interaction

Summary

ButterflyNet provides technology support for the growing problem of mobile information capture and access

Open Source Software Project

Broader Impact

- Medicine, Anthropology*, HCI…

Looking for Potential Collaboration in our current / future projects

http://**hci.stanford.edu**/bio

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