Field Techniques for Measuring Vegetation

Session Objectives

- Describe qualitative techniques suitable for plant and vegetation monitoring.
- Describe advantages, disadvantages, and uses of measures of density, frequency, and cover.
- Compare methods for measuring cover:
  - Visual estimation in quadrats
  - Line intercepts
  - Point intercepts

Qualitative vs. Quantitative Monitoring

- Qualitative monitoring can be quite effective
  - It's the most common monitoring approach
  - Photographs often more effective than statistics particularly if change is obvious
  - Photos, presence/absence, checklists
  - Still need management objective

- Quantitative monitoring must be used wisely
  - Useless without good mgmt/sampling objectives and management response
  - Pilot study necessary before sinking too much $$$
  - Don't use quantitative approach if can't do it right

Qualitative Techniques

- Presence/absence
- Visual estimates of population size
- Estimates of population condition
- Site condition assessment
- Boundary mapping
- Photo plots
- Photo points

Presence/Absence

- Does the species still occur at a site?
- Advantage: no particular skills required other than being able to ID the plant.
- Disadvantage: no information on trend, except when species disappears.
- Especially useful for large or showy plants that grow along roads and are visible in a "drive-by."
- Use of a short form improves utility.

Visual Estimates of Population Size

- Advantage: provides a gross index of population trend.
- Disadvantage: because of variability among observer estimates, only large changes can be monitored with confidence.
- Guidelines and training can improve repeatability:
  - Stratify populations that are large or spread over a large area.
  - Use classes rather than requiring an actual number.

Estimates of Population Size Using Logarithmic Classes

Population Size Class	Number of Plants
0	0
1	1 - 10
2	11 - 100
3	101 - 1000
4	1001 - 10000
5	> 10000

Estimates of Population Condition

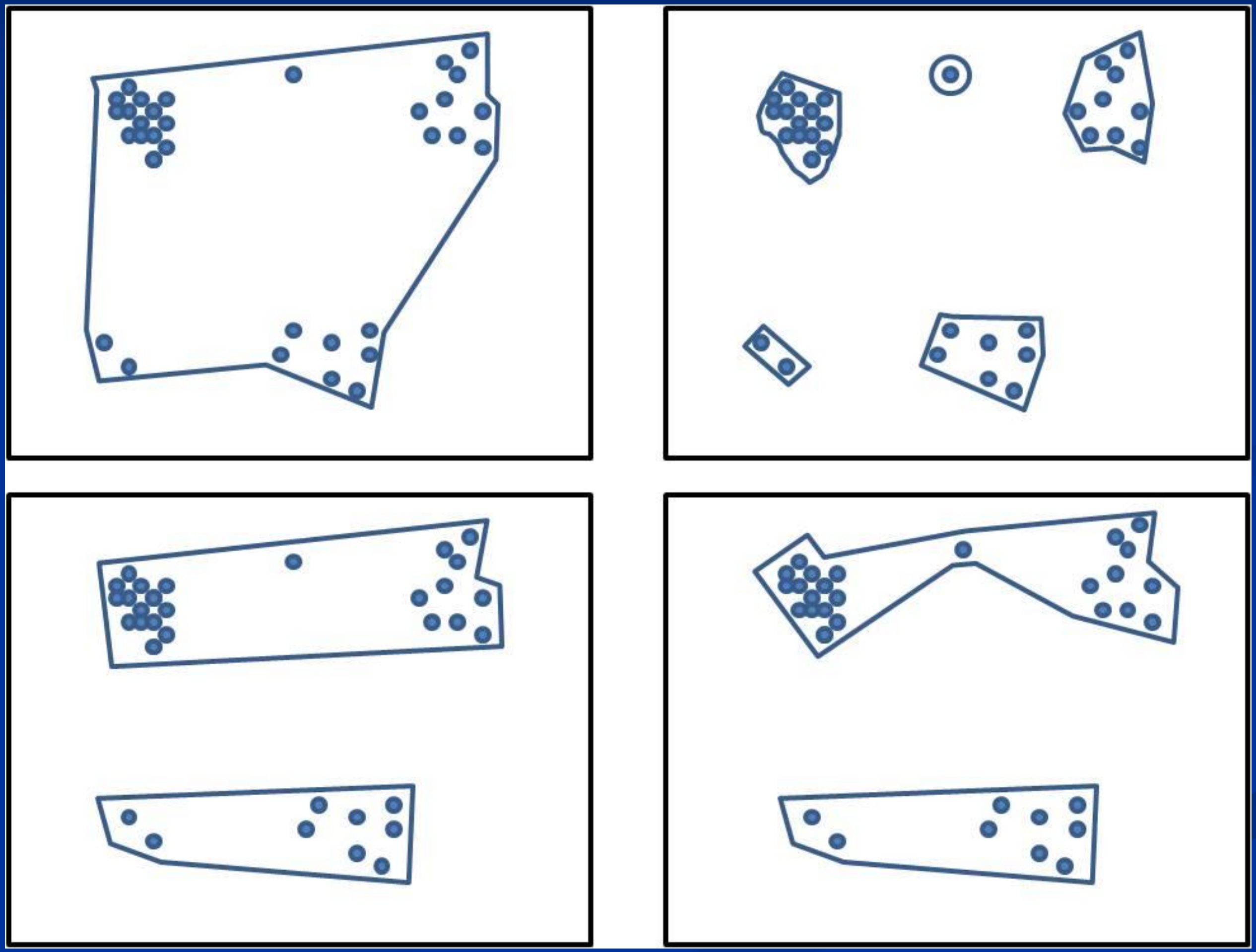
- Can develop standard field observation sheets.
- Data fields will vary by species, habitat, situation.
- Some possibilities:
  - Estimated number of individuals.
  - % of individuals in stage class.
  - % of individuals that are vegetative, flowering, fruiting.
  - Association of stage classes with habitat features (e.g., location of seedlings).
  - Evidence and degree of herbivory, disease.
  - Pollinators and/or dispersal agents observed.

Site Condition Assessment

- Evaluates the condition of the habitat through repeated subjective measurements.
- Can focus on a single activity, potential disturbance, or site characteristic.
- Training and the use of photos illustrating condition categories can reduce between-observer differences.
- Most effective when articulated in quantitative way: e.g., estimate size or areal extent of weed population—instead of "common," "rare."

Boundary Mapping

- Must have consistent rules
- Here are 4 ways of mapping the same occurrence



Qualitative Monitoring – field survey forms, checklists

Mail to:
California Natural Diversity Database
Department of Fish and Game
1807 13th Street, Suite 202
Sacramento, CA 95814
Fax: (916) 324-0475 email: WHDAB@dfg.ca.gov

For Office Use Only
Source Code ____________ Quad Code ______________
Elm Code ______________ Occ. No. ______________
EO Index No. ___________ Map Index No. ____________

Date of Field Work mm/dd/yyyy: ______________

Reset

California Native Species Field Survey Form

Send Form

Scientific Name:

Common Name:

Species Found? ☐ Yes ☐ No ______________ If not, why?

Total No. Individuals _______ Subsequent Visit? ☐ yes ☐ no

Is this an existing NDDB occurrence? _______ Yes, Occ. # ☐ no ☐ unk.

Collection? If yes: _______ Number _______________ Museum / Herbarium

Reporter: ______________
Address: ______________
E-mail Address: ______________
Phone: ______________

Plant Information

Phenology: ____% vegetative ____% flowering ____% fruiting

Animal Information

____ # adults ____ # juveniles ____ # larvae ____ # egg masses ____ # unknown

☐ breeding ☐ wintering ☐ burrow site ☐ rookery ☐ nesting ☐ other

Location Description ***(please attach map AND/OR fill out your choice of coordinates, below)***

County: ______________ Landowner / Mgr.: ______________
Quad Name: ______________ Elevation: ______________
T____ R __ Sec ____ , ____ ¼ of ______ ¼, Meridian: H☐ M☐ S☐ Source of Coordinates (GPS, topo. map & type): ___________
T____ R __ Sec ____ , ____ ¼ of ______ ¼, Meridian: H☐ M☐ S☐ GPS Make & Model ______________
Datum: NAD27☐ NAD83☐ WGS84 ☐ Horizontal Accuracy ______________ meters/feet
Coordinate System: UTM Zone 10 ☐ UTM Zone 11 ☐ *OR* Geographic (Latitude & Longitude) ☐
Coordinates: Easting/Longitude ______________ Northing/Latitude ______________

Habitat Description *(plant communities, dominants, associates, substrates/soils, aspects/slope):*

Other rare taxa seen at THIS site on THIS date:

Site Information Overall site quality: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Current / surrounding land use:

Visible disturbances:

Threats:

Comments:

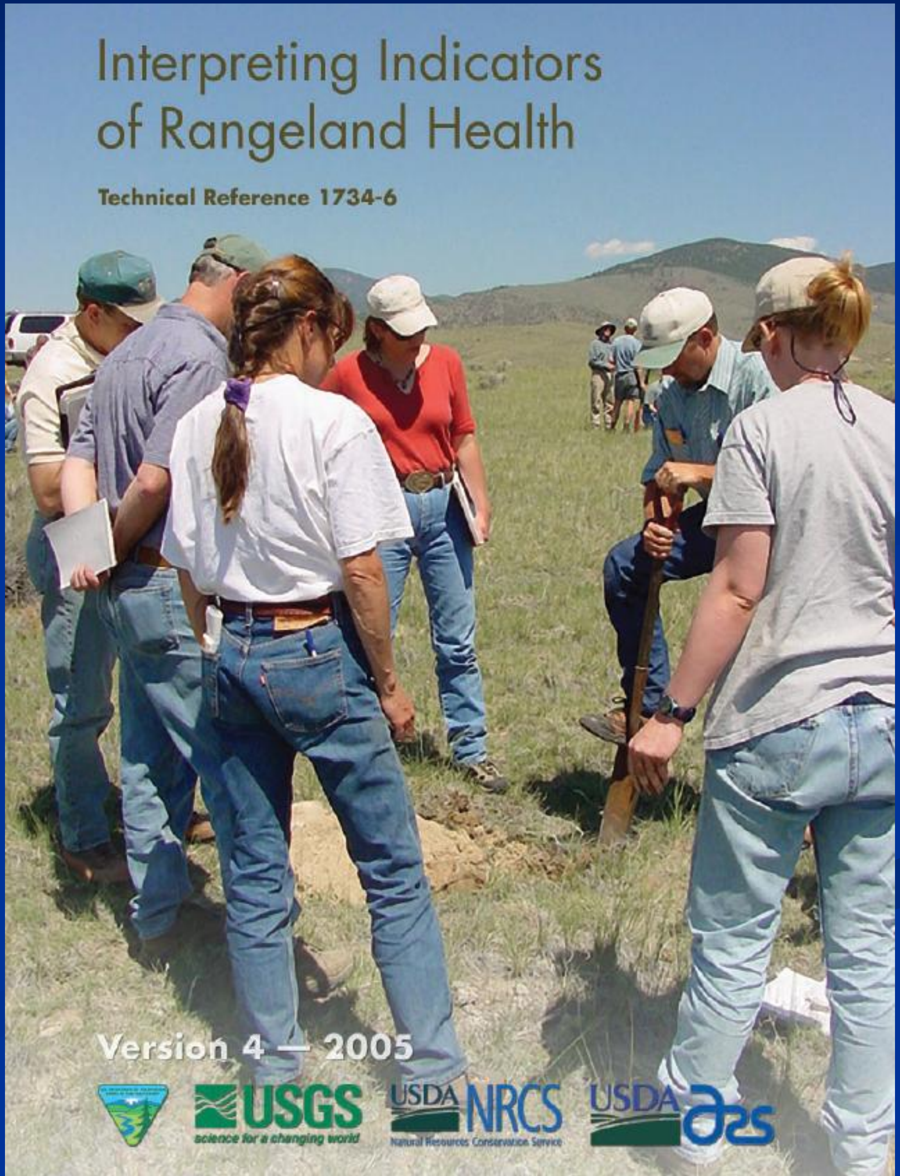
Determination: *(check one or more, and fill in blanks)*
☐ Keyed (cite reference): ______________
☐ Compared with specimen housed at: ______________
☐ Compared with photo / drawing in: ______________
☐ By another person (name): ______________
☐ Other: ______________

Photographs: *(check one or more)*

	Slide	Print	Digital
Plant / animal	☐	☐	☐
Habitat	☐	☐	☐
Diagnostic feature	☐	☐	☐

May we obtain duplicates at our expense? ☐ yes ☐ no

FG/WHDAB/1747 Rev.10/20/03



Reference Area

Evaluation Area

Evaluation Sheet (Example) (Back)

Departure from Expected	Code	Instructions for Evaluation Sheet, Page 2
None to Slight	N-S	(1) Assign 17 indicator ratings. If indicator not present, rate None to Slight.
Slight to Moderate	S-M	(2) In the three grids below, write the indicator number in the appropriate column for each indicator that is applicable to the attribute.
Moderate	M	(3) Assign overall rating for each attribute based on preponderance of evidence.
Moderate to Extreme	M-E	(4) Justify each attribute rating in writing.
Extreme to Total	E-T	

Indicator	Rating	Comments
1. Rills	S H / M	Active rill formation evident at infrequent intervals
2. Water-flow Patterns	S H / M-E	Flow patterns show cutting and deposition and some connectivity
3. Pedestals and/or terracettes	S H / S-M	Pedestalling in flow patterns only not common
4. Bare ground 48 %	S H / M	Bare ground rarely connected
5. Gullies	S H / N-S	
6. Wind-scoured, blowouts, and/or deposition areas	S / N S	
7. Litter movement	S / M	Small litter shows sign of moderate movement, larger litter - slight movement
8. Soil surface resistance to erosion	S H B / M-E	Stability values average from 3-4 on surfaces under vegetation canopy and 1-2 in interspaces
9. Soil surface loss or degradation	S H B / M	Severe past erosion has left much of the site without much surface horizon
10. Plant community composition and distribution relative to infiltration	H / M-E	Change from grass dominated to shrub dominated has decreased infiltration and bare ground has increased run-off
11. Compaction layer	S H B / N-S	
12. Functional/structional groups	B / M	Subdominate group basically gone (warm season stoloniferous grass) and Subdominate group (warm season narrow leaf bunchgrass) and Minor group (Evergreen subshrub) have
13. Plant mortality/decadence	B / S M	
14. Litter amount	H B / M-E	Very little litter is on the site for the time of year and rainfall for the year
15. Annual production	B / S M	Production is about 70% of expected
16. Invasive plants	B / N S	
17. Reproductive capability of perennial plants	B / S M	Plants show some signs of stress that will reduce seed production and stolon production this year

E-T	M-E	M	S-M	N-S
		9		
		7		11
	8	4		6
	2	1	3	5

S (10 indicators):
Soil & Site Stability
Rating: M

Attribute Rating Justification
Soil & Site Stability: Although there is some active erosion in flow patterns, most is old and healing. Lots of water leaving the site, but not much erosion. All erosion occuring as concentrated flow.

E-T	M-E	M	S-M	N-S
	14			
	10	9		
	8	4		11
	2	1	3	5

H (10 indicators):
Hydrologic Function
Rating: M-E

Attribute Rating Justification
Hydrologic Function: Lots of water leaving the site. Runoff is increasing and all litter is being washed away.

E-T	M-E	M	S-M	N-S
			17	
	14	12	15	16
	8	9	13	11

B (9 indicators):
Biotic Integrity
Rating: M

Attribute Rating Justification
Biotic Integrity: Shift in functional structural groups is significant, justifying moderate rating.

RIPARIAN AREA MANAGEMENT

TR 1737-15 1998

A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas

U.S. Department of the Interior
Bureau of Land Management

U.S. Department of Agriculture
Forest Service

USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

Standard Checklist

Name of Riparian-Wetland Area:____________________

Date:____________ Segment/Reach ID: ____________

Miles:____________ Acres:____________

ID Team Observers: ____________________

Yes	No	N/A	HYDROLOGY
			1) Floodplain above bankfull is inundated in "relatively frequent" events
			2) Where beaver dams are present they are active and stable
			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
			4) Riparian-wetland area is widening or has achieved potential extent
			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
			6) There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
			7) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)
			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high-streamflow events
			10) Riparian-wetland plants exhibit high vigor
			11) Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows
			12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION/DEPOSITION
			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) are adequate to dissipate energy
			14) Point bars are revegetating with riparian-wetland vegetation
			15) Lateral stream movement is associated with natural sinuosity
			16) System is vertically stable
			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

(Revised 1998)

Photographic Monitoring

- Photographs should be a routine part of all monitoring projects.
- See hints section of Measuring and Monitoring Plant Populations (pages 164-166).
- References by Hall are included on CD.

Photo Plot Monitoring

- Photos taken vertically of a quadrat.
  - 3 ft x 3 ft commonly used by BLM.
  - 5 ft x 5 ft have also been used—requires step ladder.
- Discussed in Sampling Vegetation Attributes Interagency TR

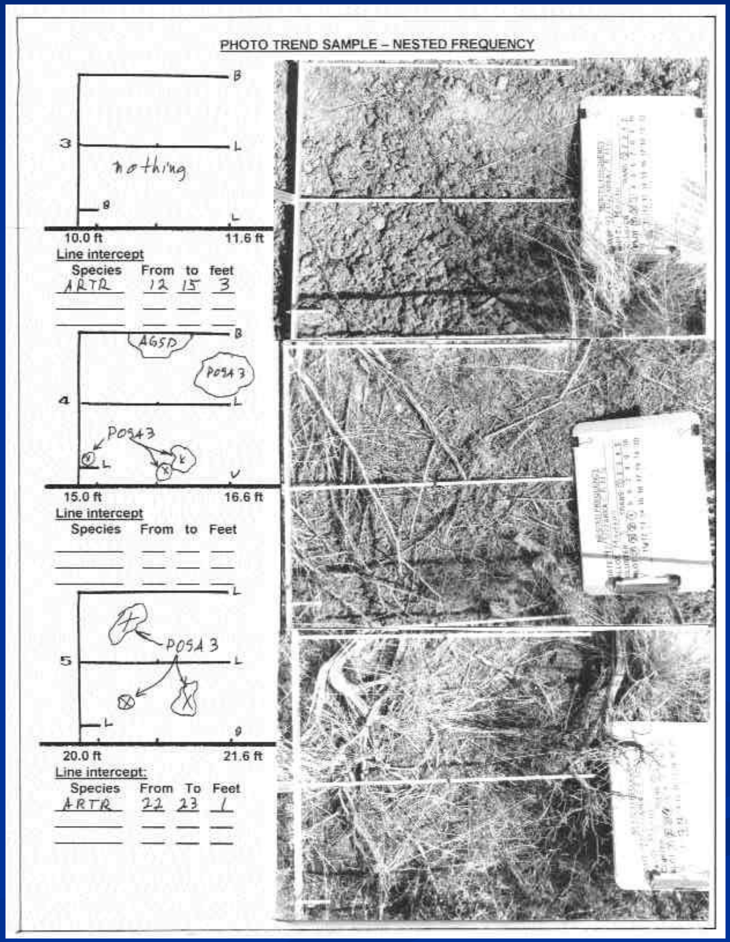
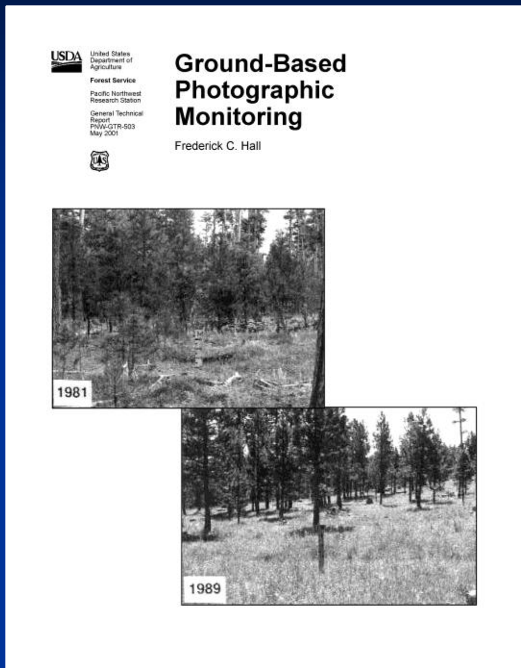


Photo Point Monitoring


USDA United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

General Technical Report PNW-GTR-503 May 2001

Ground-Based Photographic Monitoring

Frederick C. Hall

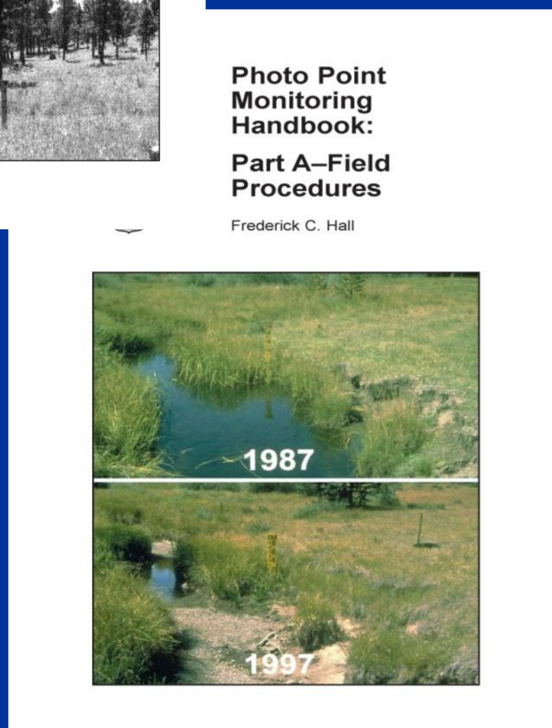
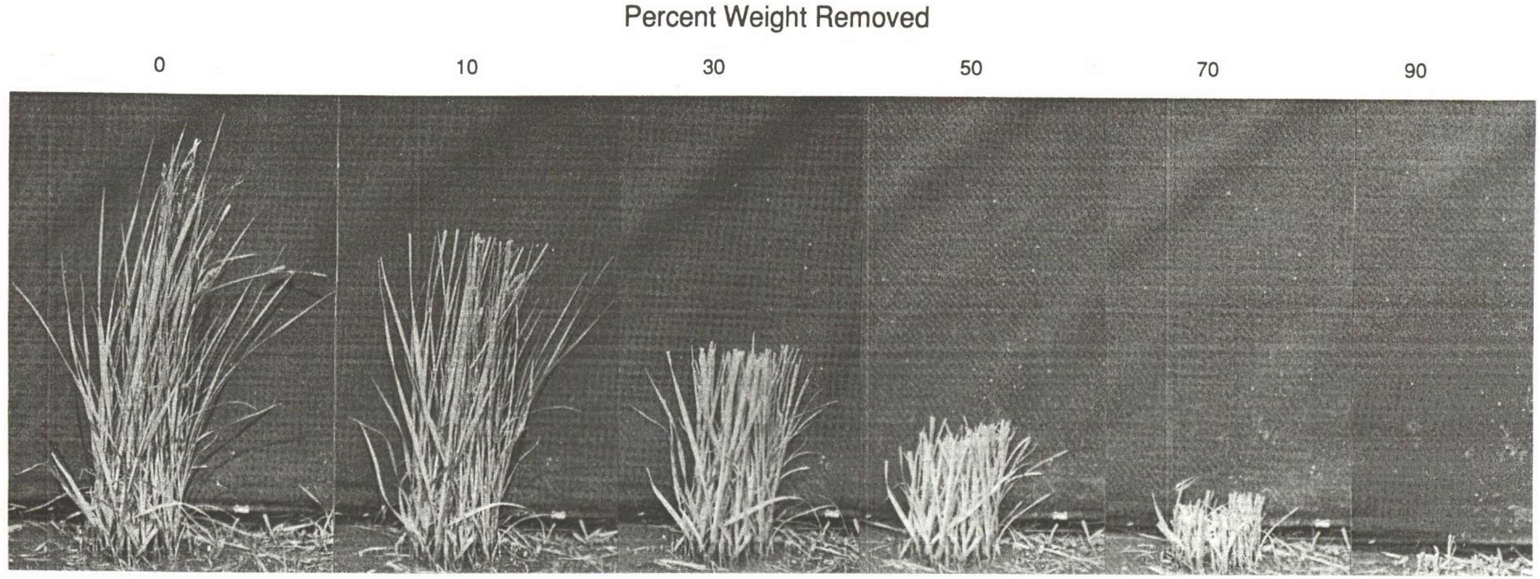


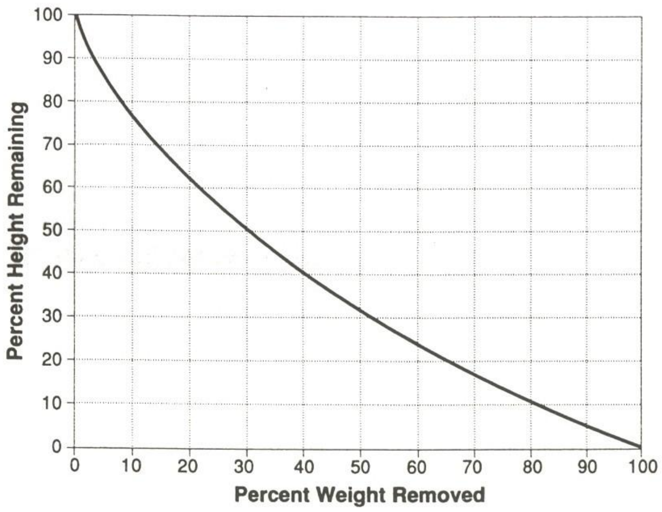
Photo Point Monitoring Handbook:

Part A–Field Procedures

Frederick C. Hall

Nebraska sedge (*Carex nebrascensis* Dewey)





Plants coarse, stems stout and sharply triangular, vigorously rhizomatous, leaves firm, blue-glaucous

2 to 10 dm tall

Flowering period July to September

Seed set August

Palatability high

Wet meadows and other wet places, often in alkaline areas

Lower to middle elevations

Photographic Monitoring

Aerial photography can be a valuable tool for monitoring threats to habitat, e.g., ORV impacts

National Aerial Photography Program (NAPP)

Hand-held digital camera

Quantitative Monitoring: Complete Census

- No statistics required for analysis of complete counts—any changes are real (assuming no counting error).
- Must have a consistent counting unit.
- Accuracy can be poor if population covers large area and/or has many individuals, there is dense vegetation, there are similar species present, or with cryptic stage classes (e.g., seedlings).
- Use systematic searching of population to improve accuracy.

Quantitative Monitoring: Sampling

- Density (which can be converted to a population total).
- Frequency.
- Cover.
  - Visual estimation in quadrats.
  - Line intercepts.
  - Point intercepts.

Density

- Density is the number of plants/unit area.
  - Counting units can be genets or ramets.
  - Critical to define and document the counting unit.
- Density usually estimated by counting individuals (or other counting units) in quadrats.

Density Pros and Cons

- Most effective when expected change is recruitment or loss of individuals (or counting units).
- Density is an absolute measurement (though precision will vary with quadrat/size shape).
  - Can compare between sites/years even if different quadrat size/shapes used.
- Density less sensitive to changes that are vigor related, especially those that are sublethal.

2005

39 individuals

- 14 reproducing (r)
- 14 nonreproducing (n)
- 11 seedlings (s)

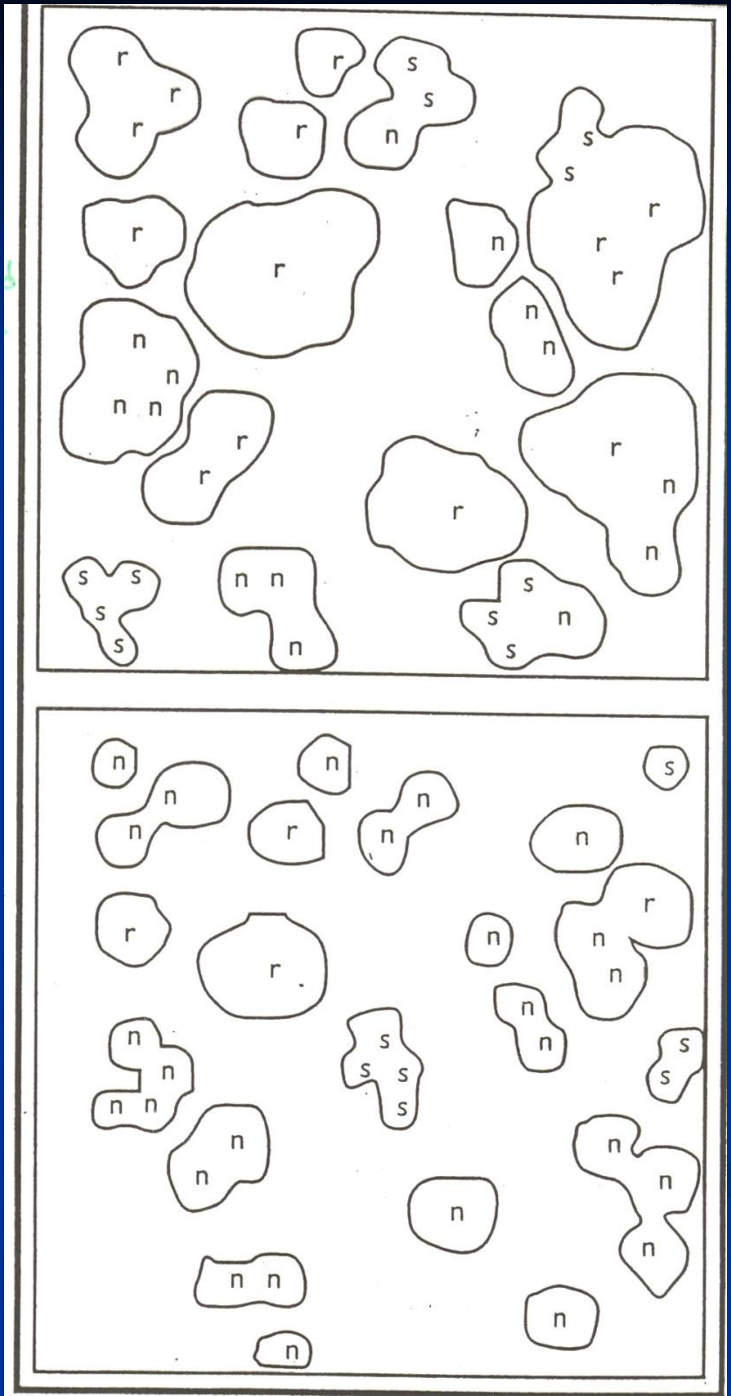
Cover > 2006

2006

37 individuals

- 4 reproducing (r)
- 26 nonreproducing (n)
- 7 seedlings (s)

Cover <2005

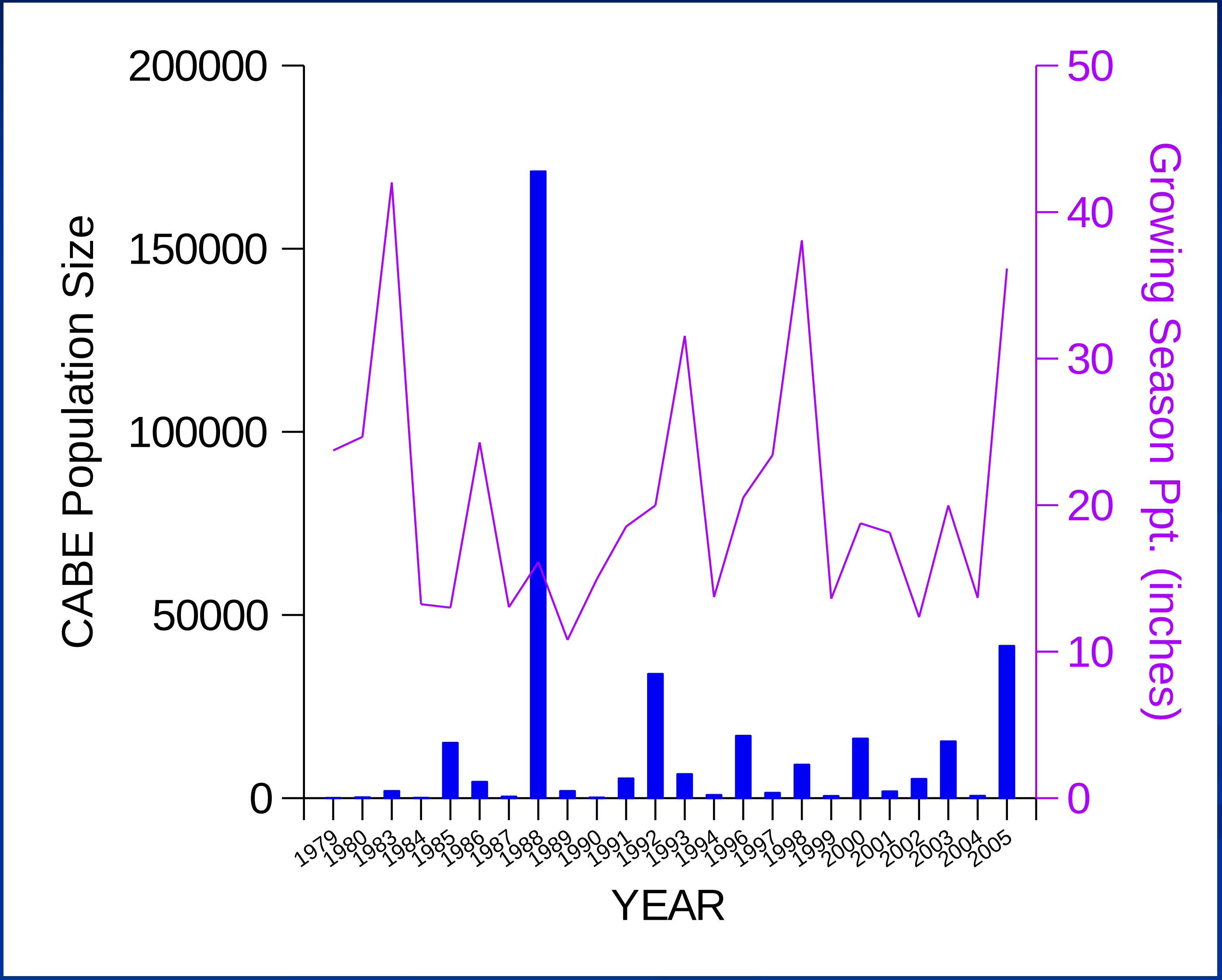


Density Pros and Cons (cont'd)

- Observer bias is low if counting units are few and easily recognized, but errors are common when quadrats contain cryptic individuals or numerous plants.
- Density may be an especially poor measure when individuals are long-lived and respond to stress with reduced biomass or cover, rather than mortality.
- Also maybe poor for plants that fluctuate dramatically from year-to-year (e.g., annuals).

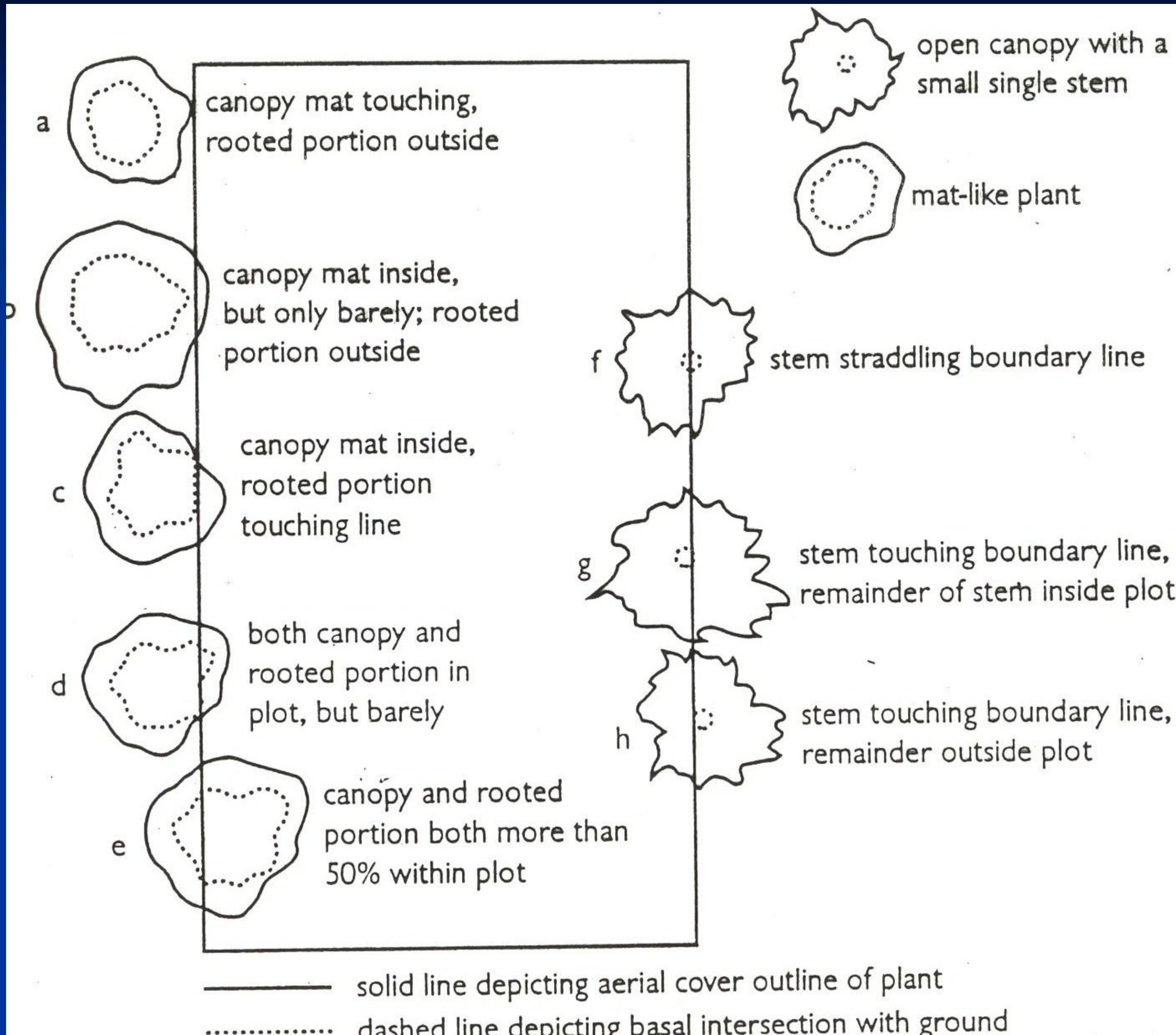
Monitoring Problem: Annual Plants

Camissonia benitensis



Density: Field Considerations

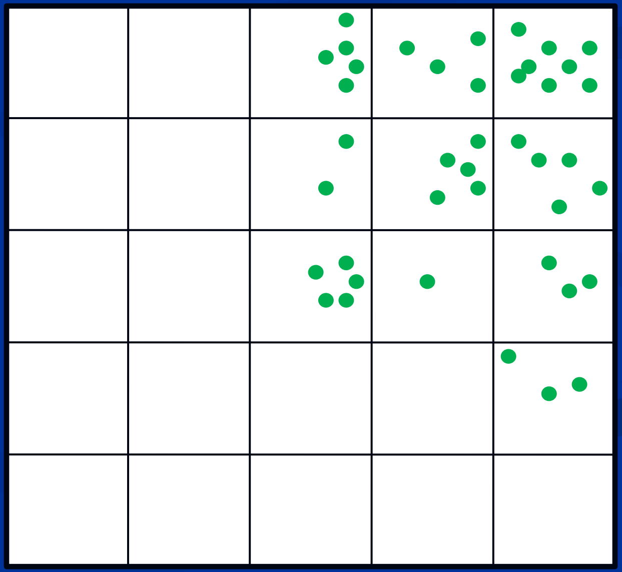
- Quadrat design (Dan will cover in detail).
  - Size of quadrat needs to be practical.
  - Size and shape of quadrat needs to be tailored to specific plant distribution observed.
- Counting unit.
  - Must be consistent and recognizable.
  - Density not applicable to all life forms.
  - Usually use rooted density, but problematic for matted plants—can use canopy outline or cover.
  - Consider the value of counting by stage classes.
- Boundary decisions.


open canopy with a small single stem
mat-like plant
a
canopy mat touching, rooted portion outside
b
canopy mat inside, but only barely; rooted portion outside
c
canopy mat inside, rooted portion touching line
d
both canopy and rooted portion in plot, but barely
e
canopy and rooted portion both more than 50% within plot
f
stem straddling boundary line
g
stem touching boundary line, remainder of stem inside plot
h
stem touching boundary line, remainder outside plot
solid line depicting aerial cover outline of plant
dashed line depicting basal intersection with ground

Frequency

- Frequency is measured in quadrats.
- It is the percentage of all possible quadrats that can be placed (w/o overlap) in the sampled area that is occupied by the target species.

True population frequency = 10/25 = 40%



Frequency Pros

- Appropriate for any life form (unlike density).
- Very sensitive to changes in spatial distribution.
- May be good for some annuals whose density may vary greatly between years but whose spatial arrangement of germination remains stable.
- Rhizomatous species, especially graminoids, often measured with frequency—no need to define counting unit.

Frequency Pros (cont'd)

- Good measure for monitoring invasions of undesirable species.
- Longer time window for sampling than cover—cover can change dramatically from week to week.
- The key advantage:
  - The only decision required by the observer is whether species occurs in the quadrat.
  - Little training required.
  - If species easy to spot, quadrats evaluated quickly.

Frequency Cons

- Frequency is a relative measure and completely dependent on quadrat size and shape.
  - Can’t compare between years and sites if different quadrat sizes are used.
- Frequency is affected by both spatial distribution and density of the population.
  - Changes can be difficult to interpret because we don’t know if change due to changes in density, spatial distribution, or both.

Macroplot sampled in 2 different years with 40 permanent frequency plots.

Year 1

Frequency = 58%

Density = 198 individuals

72 seedlings (*)

126 adults (X)

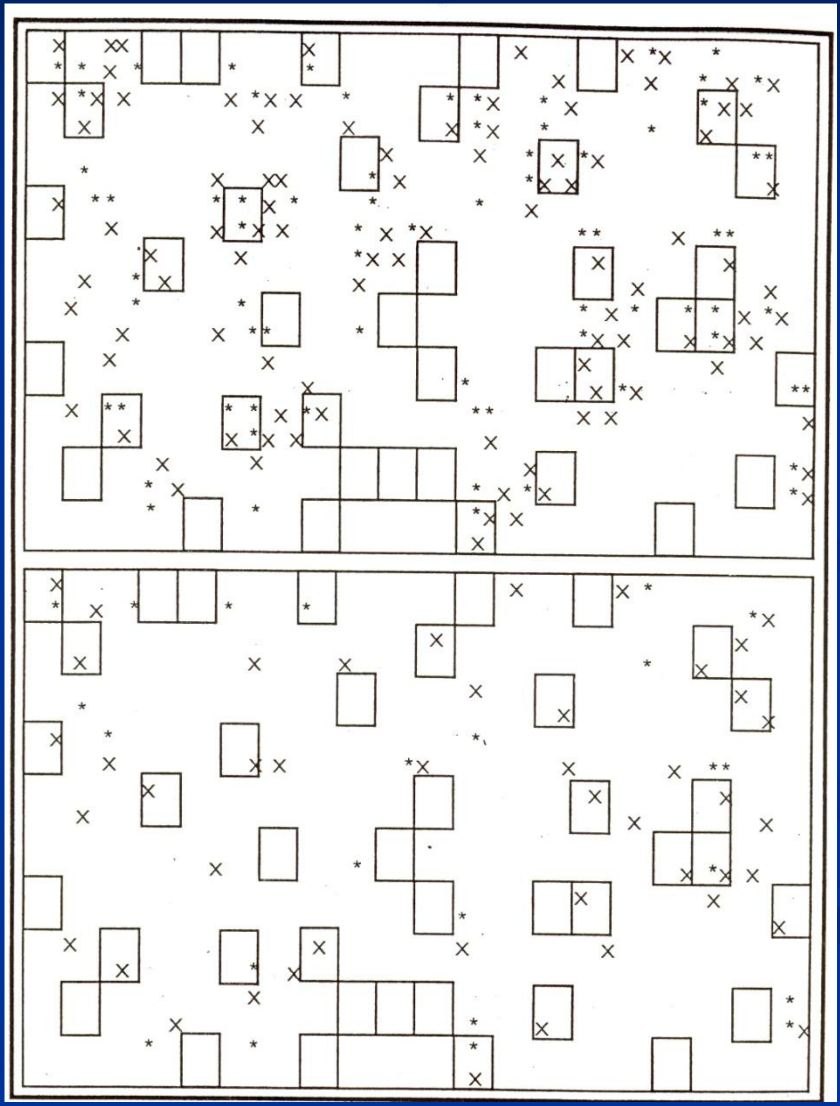
Year 2

Frequency = 50%

Density = 71 individuals

23 seedlings (*)

48 adults (X)



Frequency Cons (cont’d)

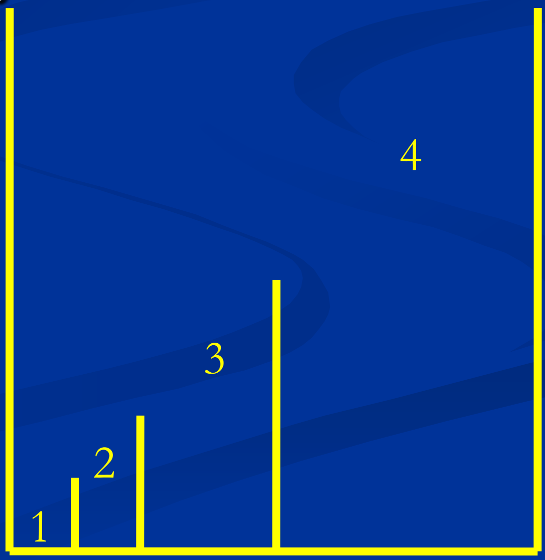
- Unlike other vegetation attributes such as cover or density, frequency is difficult to estimate for a whole site.
- Thus, the biological significance of changes may be difficult to convey to managers and user groups because they can’t easily visualize the change.

Frequency: Field Considerations

- Positioning of quadrats.
  - Simple random placement is inefficient.
  - Usually position quadrats systematically (w/ random start) along transects that are systematically (w/ random start) positioned perpendicular from baseline.
- Boundary rules—usually include plant only if rooted.
- Stage classes.
  - Consider collecting information by stage class.
  - Conveys more information and makes changes easier to interpret.

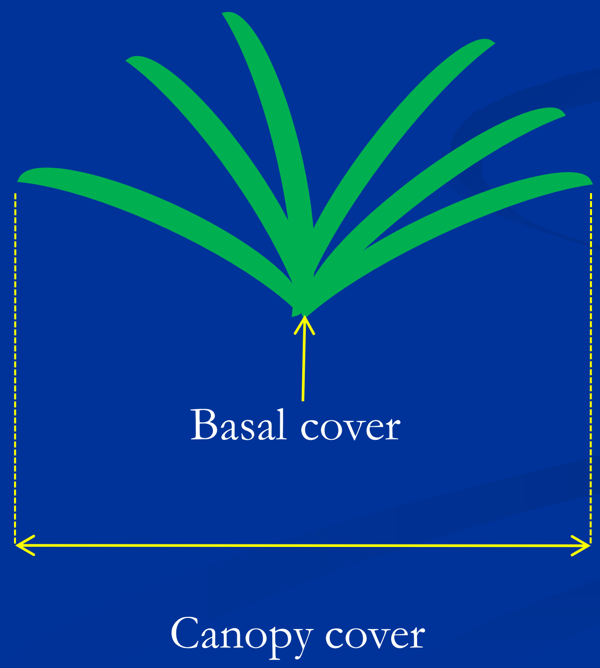
Frequency Quadrat Size and Shape

- Square quadrats are fine.
- The larger the quadrat the higher the frequency value.
- Should strive to have frequency between 30%-70%.
- Usually use nested quadrat →
  - Can be used for diff species.
  - Or different stages of 1 species.



Cover

- Two types:
  - Basal cover: area where plant intersects the ground (at breast height for trees).
  - Canopy (or aerial) cover: vegetation covering the ground surface by canopy of plant (bird's eye view).



Cover Pros

- Applicable to all types of plants.
- Cover is an absolute measurement--can compare between sites/years even if different methods used.
- Often used for graminoids because of difficulty in counting plants or tillers.
- One of most common measures of community composition--equalizes contribution of species that are small but abundant and species that are large but few.

Cover Pros (cont'd)

- Cover more directly related to biomass than density or frequency.
- Doesn't require the identification of an individual plant (as density), yet easily visualized and intuitive (unlike frequency).

Cover Cons

- Canopy cover can change dramatically over the course of a growing season.
  - Frequency and density measures are fairly stable in the growing season after germination is complete.
  - The change during growing season may make it hard to compare results from different parts of large areas when sampling is over period of weeks to months.
- Canopy cover changes may differ greatly between years due to weather alone.

Cover Cons (cont'd)

- Cover is sensitive to both changes in density and in vigor (annual biomass production).
  - This may make cover changes difficult to interpret.
  - For plants with relatively little annual variability in canopy cover—such as shrubs and matted perennials—cover changes will be due primarily to mortality and recruitment.
  - Real trends in density may be obscured in species with highly variable annual production.

2005

Density 39 individuals

14 reproducing

14 nonreproducing

11 seedlings

Cover < 2006

2006

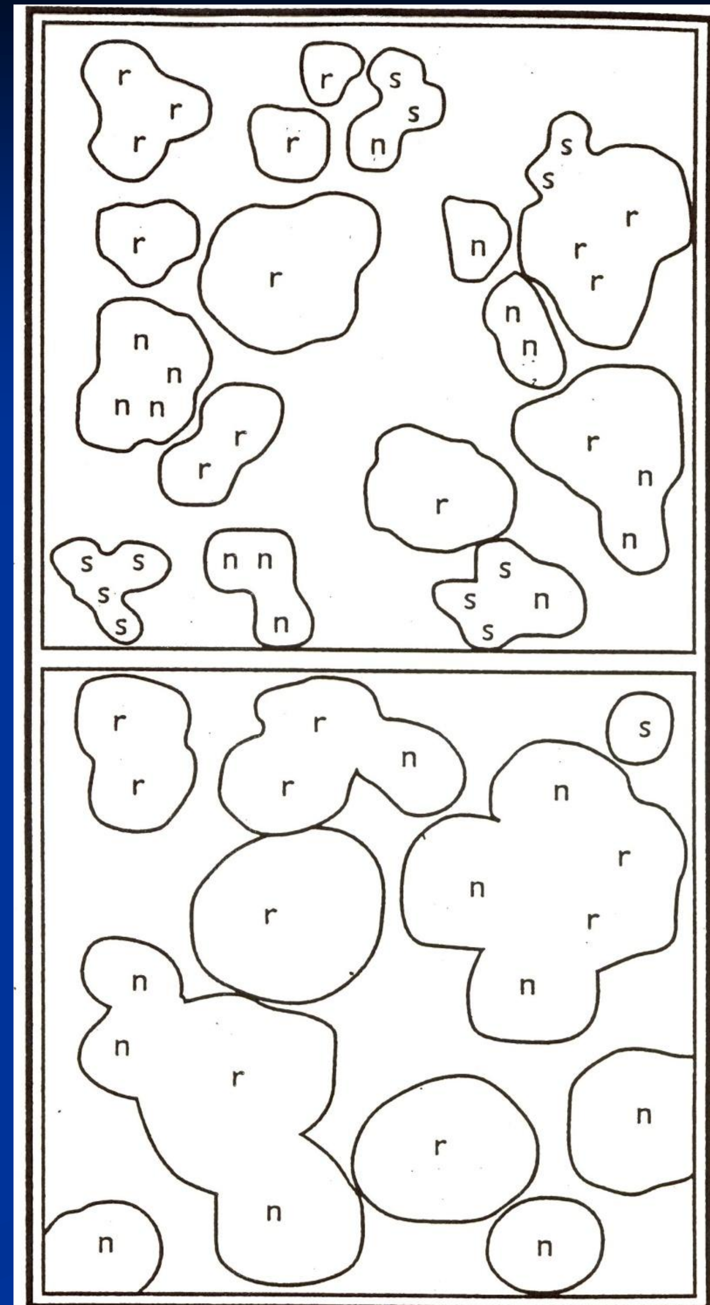
Density 20 individuals

9 reproducing

10 nonreproducing

1 seedling

Cover > 2005



Cover: Visual Estimation in Quadrats

- Often use cover classes.
  - Many cover classes have been developed (page 179).
  - One example is that employed by Daubenmire:

Cover Class	Cover
1	>0 – 5%
2	6% - 25%
3	26% - 50%
4	51% - 75%
5	76% - 95%
6	96% - 100%

  - Class midpoints are used in the analysis

Visual Estimation Pros and Cons

- More likely to estimate cover of rarer species than with point or line intercepts.
- Key problem: unknown level of observer bias.
  - Several studies have reported on this problem.
  - Training is critical.
  - Using relatively small quadrats that are gridded or have increments painted on the quadrat sides helps reduce this problem.


1%
5%
25%
50%
75%

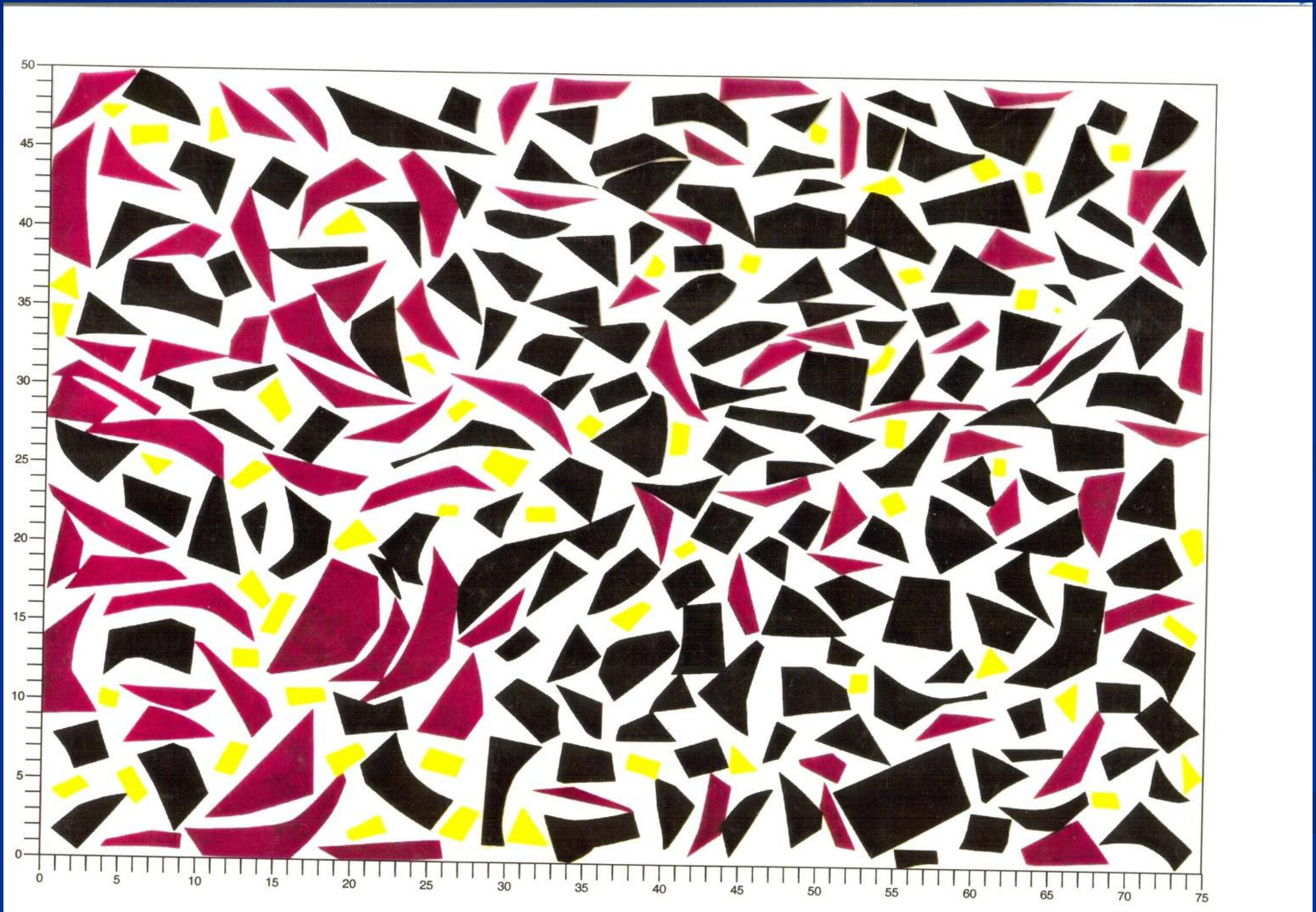
Cover

Yellow: 3.5%

Red: 16.0%

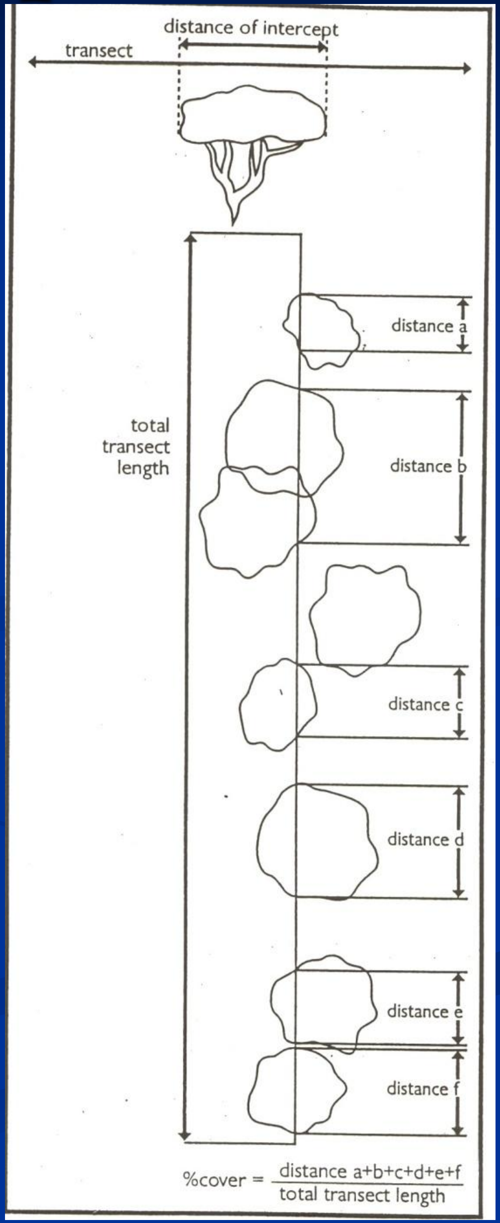
Black: 32.0%

White: 48.5%



Cover: Line Intercept

- Canopy cover is measured along a tape by noting the point along the tape where the canopy begins and the point at which it ends.
- When these intercepts are added and the sum divided by the total line length the result is a percent cover estimate for that transect.



Line Intercept Pros and Cons

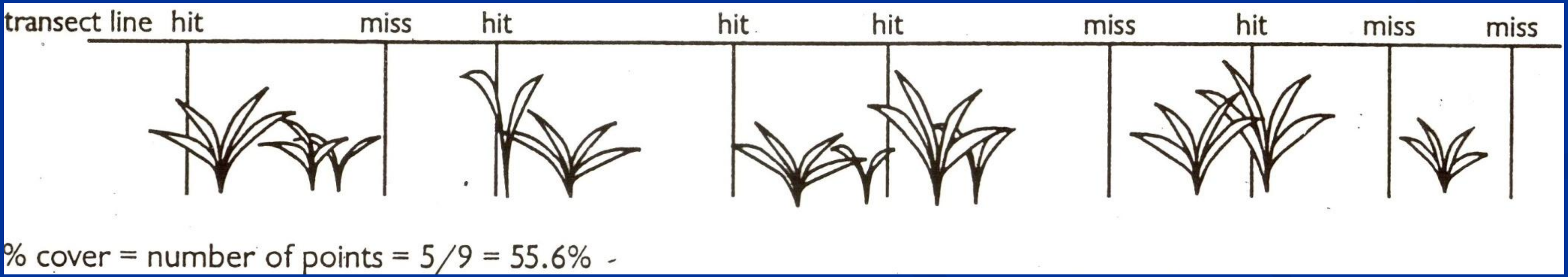
- Has been used effectively for plants with dense canopies—matted plants and many shrubs.
- Very time-consuming and difficult for plants with lacy or narrow canopies because of the large number of small interceptions.

Line Intercept Pros and Cons

- Must have rules dealing with gaps in canopy.
  - Observer can assume a closed canopy until gap exceeds a predetermined width.
  - Bonham suggests 2 cm. I've used gaps much larger than this.
  - If you develop your own rule, document it!
- Potential for observer bias if sighting line not perpendicular to tape.
- Repeatable measures difficult if wind is blowing.

Cover: Point-Intercept

- Cover is measured based on the number of "hits" on the target species out of the total number of points measured.



- Point intercept is considered the least biased and most objective of the 3 cover methods.
  - Only decision is whether point intercepts target species.
  - No canopy gaps or cover estimates to be dealt with.

Cover: Point Intercept

- Points are measured either with pins, lasers, or a crosshair sighting device.
- Pins are inexpensive and easy to use.
  - They can be used to measure cover at different canopy layers.
  - Must ensure pin is sharp—if not, it will overestimate cover, especially for narrow or small-leaved species.
  - If primary interest is detecting change pin diameter less of a problem but use the same size pin.

Cover: Point Intercept

- Another issue with pins is bias associated with dropping the pin.
  - This can be avoided by using a device mounted to a tripod (see photos following this discussion).
- Laser devices have been employed by some workers in recent years (photos following).
  - Can be single laser point or mounted as frame of 10 laser points.
  - If in a frame, the frame and not the point must be the sampling unit.

Cover: Point Intercept

- An optical periscope-type sighting device has been used in cover estimation, especially in coal mine restoration in the Rocky Mountain region (see photos following).
- Both laser and optical-sighting devices will only measure a single canopy layer (except the optical device can be turned upward to measure tree canopy cover).
  - Could carefully move top canopy layer to measure lower layers but accuracy is questionable.

Optical periscope-type sighting device. Note quick-release ball head and bubble level. The end of the device can be rotated to look at tree canopy.

“Harpoon” point intercept device. Sharp point is lowered and species intercepted recorded. Can measure intercepts in several strata. Device uses same quick-release ball head and bubble level seen on periscope device.

Laser point frame developed by VanAmburg et al. (2005).

Single-point laser device developed by Alexander et al. (2004).

Moose-horn sighting device developed by Geographic Resource Solutions (they call it a densitometer). For measuring tree canopy cover.

Point Intercept Issues

- Angle of the point intercept has a big impact on the cover measure:
  - Most intercepts are perpendicular to ground but species with narrow upright leaves rarely hit.
  - Other angles have been used to increase hits.
  - Monitoring plan must specify angle used.
  - Angles other than perpendicular difficult to interpret.
    - No longer a “birds eye view.”
    - Also no longer a measure of degree of soil vulnerability to erosion.

Point Intercept Issues (cont'd)

- Wind can be a problem—more veg. surface area.
- You can record multiple interceptions at each pt.
  - No longer true canopy cover—may intercept same individual or species at each point.
  - Multiple interceptions usually interpreted as index of biomass, volume, or composition.
- Species with low cover values not sampled efficiently unless a large number of points used.
  - Not feasible in community sampling.
  - Might be feasible if sampling cover of 1 species.

Subplot Frequency as an Estimate of Cover: Just Say No!

- Some recent papers (e.g., Brakenhielm and Qinghong 1995, Carlsson et al. 2005) refer to a method called "Subplot Frequency."
- The former paper calls this a measure of cover: it isn't! Only with very small points do you get an unbiased estimate of cover.

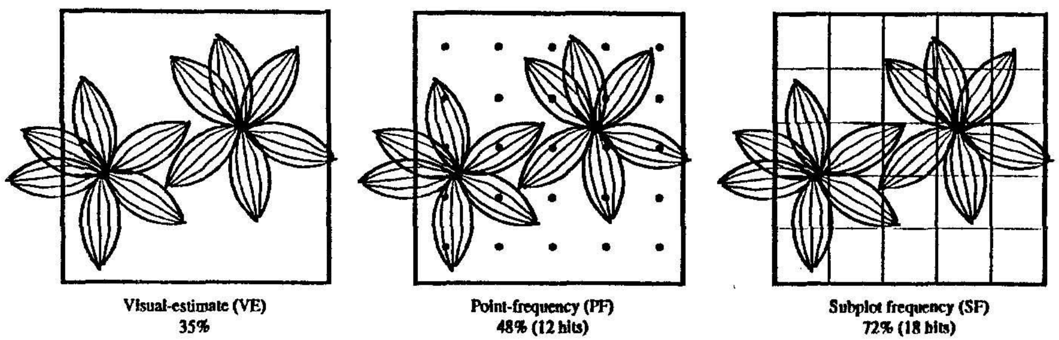


Fig. 1. Illustration of the three methods of cover estimate on an artificial plant with the estimate result below. The true cover is 37.3% as measured by a digitizing method.