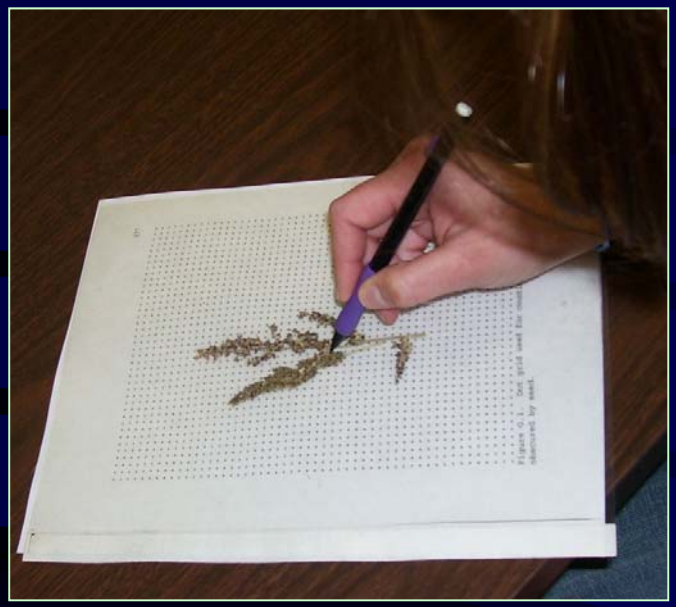
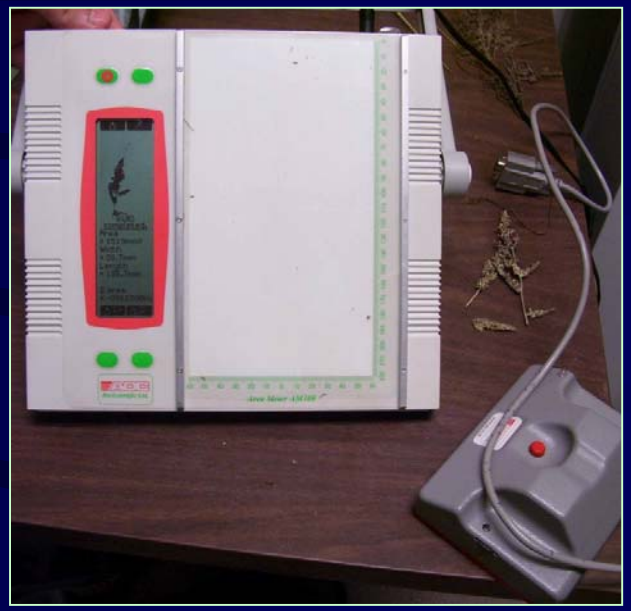
New Technology for Estimating Seed Yield in Moist-soil Wetlands





Matthew J. Gray

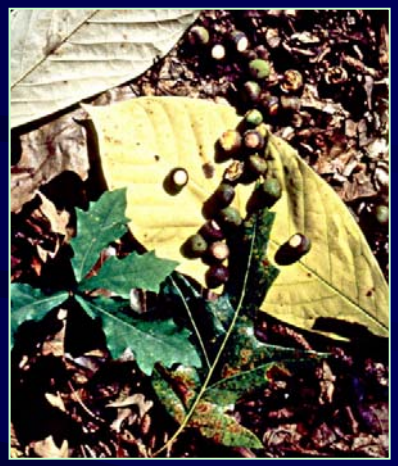
Institute of Agriculture

Wetlands Program

What do Ducks Eat??

Natural Foods

Moist-soil Seeds



Acorns

Tubers

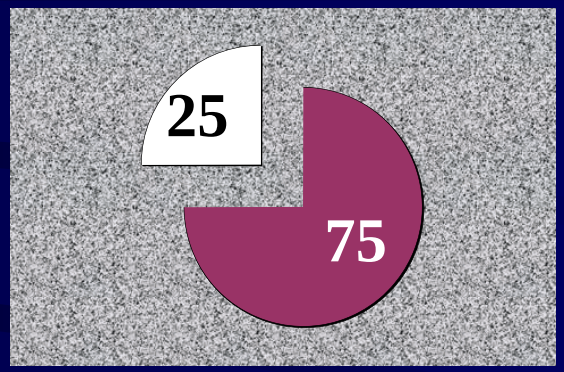
Aquatic Invertebrates

Agricultural Foods

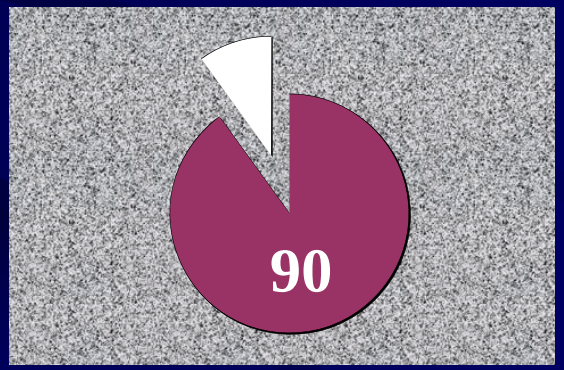
What do Dabbling Ducks Eat during Migration and Winter??

Energetically Costly Activities

- Fall Migration
- Courtship
- Thermoregulation
- Spring Migration



Migration



Winter

Seeds are Primary Diet Item

➡ **Energy-rich**

2.5 kcal / g

Providing Abundant Seed Food Resources!

Importance of Moist-soil Wetlands

Seed Production:

450 kg/ha

Exceeds Acorns & Waste Grain!

Gray et al. (1999)

- **Managed: 1200 kg/ha (50% of Milo)**
- **Unmanaged: 200 kg/ha**

Kross et al. (2008)

- **Managed/Unmanaged: 500 kg/ha**

Quantifying Duck Energy-days

Prince 1979

Reinecke et al. 1989

Reinecke and Loesch 1996

$$DED = \frac{\text{Food Available (g [dry])} \times \text{TME (kcal/g [dry])}}{\text{Daily Energy Requirement (kcal/day)}}$$

We need accurate estimates of seed production!!

Estimating Available Food for DEDs

3 Methods:

1) Constants

- An estimate of mass from previous direct sampling or published yields (i.e., crops).

Ignores Management!

2) Direct Estimate

- An estimate of mass from current direct sampling in your wetland or ag areas.

Too Time Consuming!

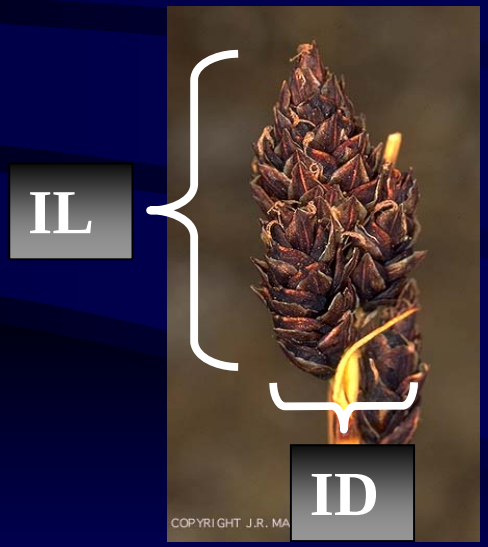
3) Prediction Models

- An estimate of mass from current indirect sampling in your wetland or ag areas.

Estimating Food Resources Using Prediction Models

(Laubhan & Fredrickson 1992; Gray et al. 1999a,b; Sherfy & Kirkpatrick 1999)

Seed Yield = $ß_0$ + $ß_1$ (Plant Morphology)



Plant Height

Variables: Easy, fast, and strongly correlated with seed production!

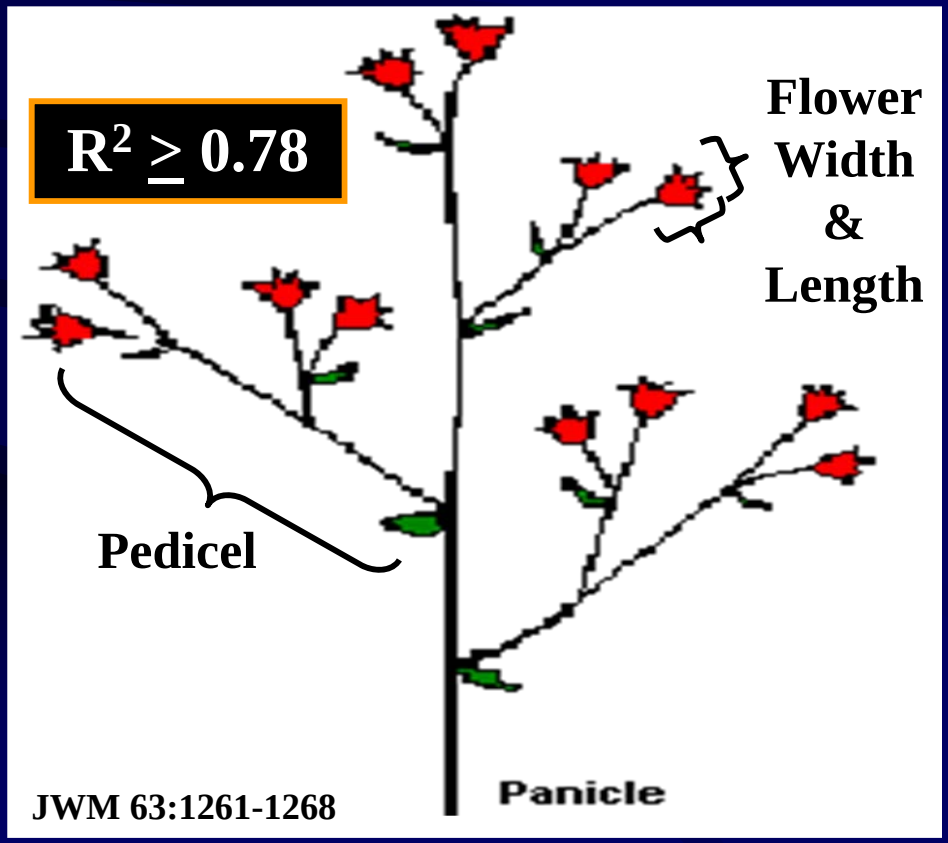
Methods: *Plant Morphological Study*

5 species:: *Echinochloa crusgalli, Cyperus erythrorhizos, Polygonum hydropiperoides, Panicum dichotomiflorum, Rynchospora globularis*

n = 60 plants/species/year, 1993 and 1994

L & F (1992)

- Plant Height
- Inflorescence Length
- Infl. Base Diameter
- Infl. Volume
- # of Inflorescences



New Variables

- Number of Pedicels
- Number of Flowers
- Flower Width
- Flower Height

Too Complex & Spatial Variability

Methods: *Dot Study*

5 species: *Echinochloa crusgalli, Setaria viridis, Panicum agrostoides, Panicum dichotomiflorum, Rynchospora globularis*

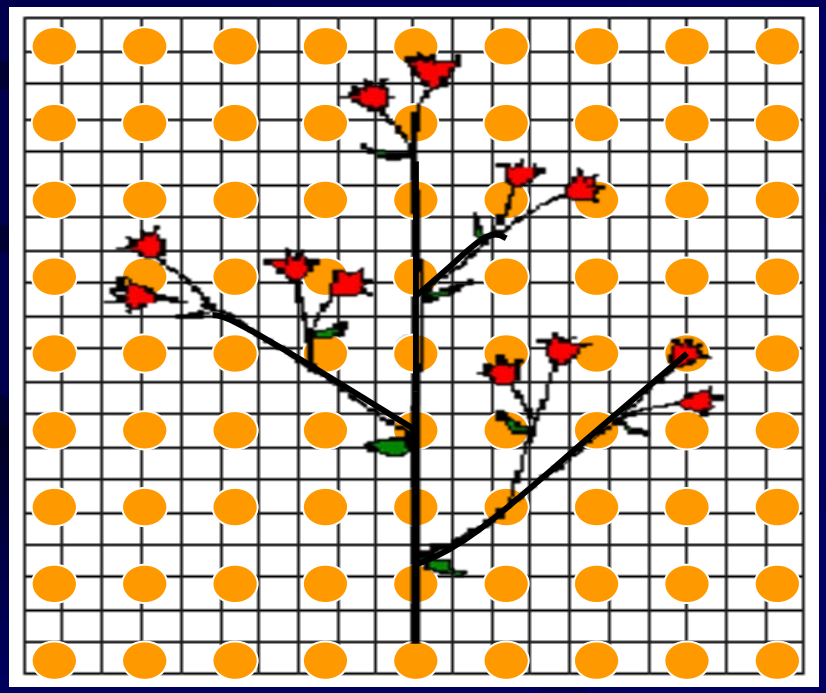
n = 30 plants/species/year, 1994

Preparation

- Plant Press
- Room Temperature
- Pedicels Separated

WSB 34:156-158

Conway, unpubl. data



JWM 63:1269-1272

$R^2 \geq 0.92$

Processing

- Dot grid (9 dots/cm^2)
- Dots Obscured by Seed Counted

Too Tedious & Time Consuming!

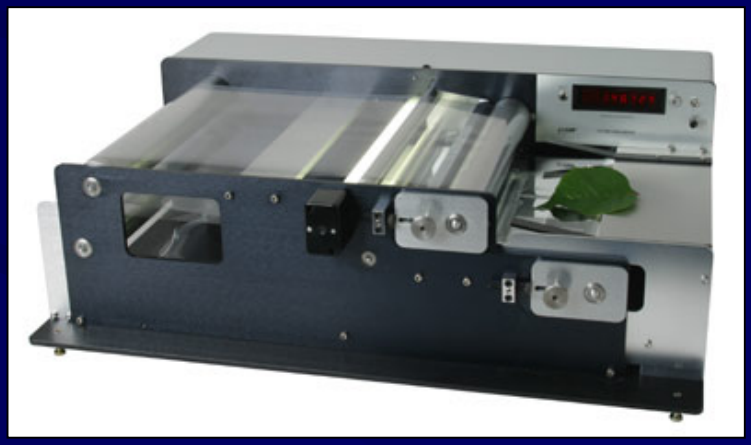
Scanning Technology

Prediction Models

Seed Head Area → **Seed Production**

Portable **Desktop**

1-mm^2 Resolution



Very fast and accurate?

Objectives

1) Test if scanned seed-head area explained significant variation in seed mass
2) Compare amount of variation explained between portable and desktop scanners and the dot grid
3) Compare amount of time necessary to scan seeds and count dots obscured by seed
4) Develop prediction models for all three methods for use in moist-soil management

7 Common Moist-soil Plant Species

Plant Species

redroot flatsedge
Cyperus erythrorhizos

barnyard grass
Echinochloa crusgalli

Walter's millet
Echinochloa walteri

rice cutgrass
Leersia oryzoides

red sprangletop
Leptochloa filiformis

fall panicum
Panicum dichotomiflorum

curlytop knotweed
Polygonum lapathifolium

Collection

September
2005 & 2006

Tennessee National Wildlife Refuge
Duck River Unit

Clipped

Bagged

Pressed &
Stored

***n* = 30 plants per species per year**

Lab Processing

Dot Grid

Specifications

9 dots / cm^2

Bolded Courier (20-pt) with 0.5 line spacing

Larger Seed Heads Cut

Dots obscured by seed were counted

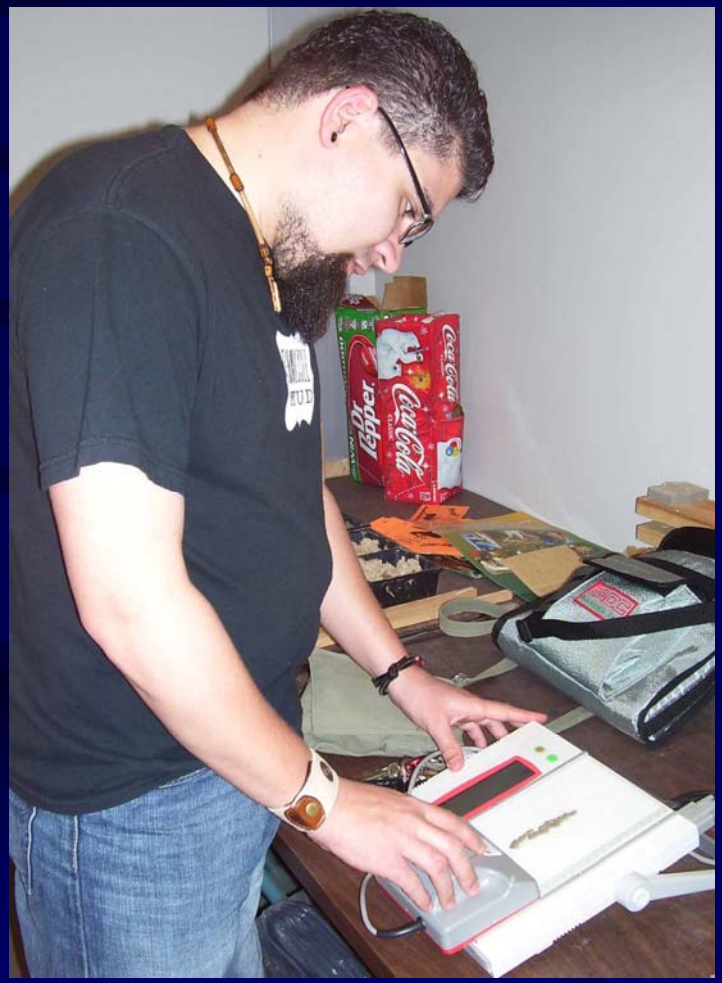
Lab Processing

Portable Scanner

ADC BioScientific

AM 300 Area Meter

$5500



Specifications

22 x 12 cm

Contrast = 5

Contrast = 3

(rice cutgrass)

Larger Seed Heads Cut

Lab Processing

Desktop Scanner

LI-COR

LI-3100 Area Meter

$9600

Specifications

25 cm (double)

Length Not Limited

All Methods

Time Processed

Lab Processing

Thresh Seeds

Dry

Weigh

Y = g seed

Statistical Analyses

Models:

$$\text{g seed} = \beta_0 + \beta_1(DOTS)$$

$$\text{g seed} = \beta_0 + \beta_1(Area\_Desk)$$

$$\text{g seed} = \beta_0 + \beta_1(Area\_Port)$$

SLR

- No Intercept
- Year Indicator

Performance: • R^2 and $R^2_{predicted}$

ANOVA: Did average processing time differ among techniques?

(Tukey's HSD)

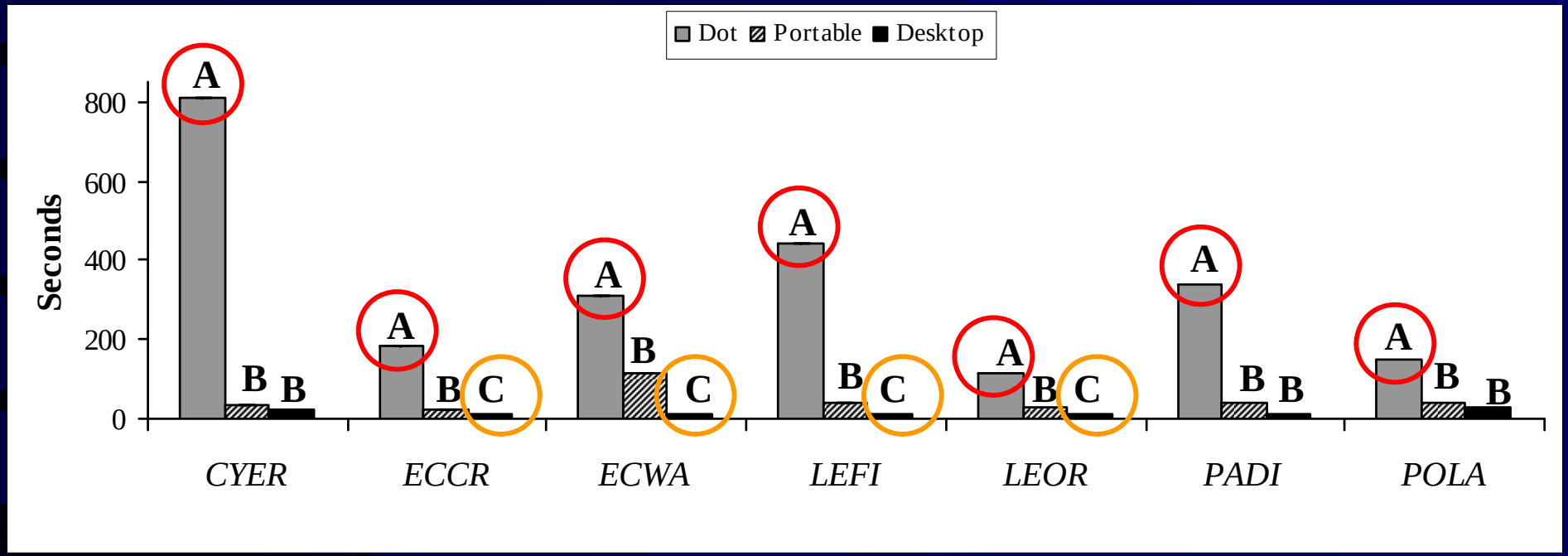
$\alpha = 0.05$

Results:

	Method	*n*	Equation	*F*	R^2	R^2_{pred}	
redroot flatsedge	Dot	59	Y = (0.002 × DOTS) + 0.247	964.2	0.970	0.968	
	Portable	59	Y = (0.016 × AREA) – 0.023	966.7	0.970	0.968	97%
	Desktop	59	Y = (0.018 × AREA) – 0.209	1070.1	0.973	0.971	
barnyard grass	Dot	60	Y = (0.004 × DOTS) – 0.044	714.7	0.960	0.956	
	Portable	60	Y = (0.023 × AREA) – 0.105	968.3	0.970	0.968	96-97%
	Desktop	60	y = (0.026 × AREA) – 0.023	982.2	0.970	0.968	
Walter's millet	Dot	60	Y = (0.003 × DOTS) + 0.057	1074.0	0.973	0.971	
	Portable	60	Y = (0.009 × AREA) + 0.032	1516.8	0.981	0.980	97-98%
	Desktop	60	Y = (0.010 × AREA) + 0.256	1178.2	0.975	0.974	
red sprangletop	Dot	59	Y = (0.0009 × DOTS) + 0.373	456.2	0.939	0.933	
	Portable	59	Y = (0.007 × AREA) + 0.421	395.1	0.930	0.923	94-96%
	Desktop	59	Y = (0.008 × AREA) + 0.301	682.2	0.959	0.955	
rice cutgrass	Dot	59	Y = (0.001 × DOTS) – 0.007	1653.2	0.983	0.981	
	Portable	59	Y = (0.007 × AREA) + 0.021	1273.9	0.977	0.976	98-99%
	Desktop	59	Y = (0.009 × AREA) + 0.009	2664.8	0.989	0.989	
fall panicum	Dot	58	Y = (0.002 × DOTS) – 0.213	900.2	0.969	0.964	
	Portable	58	Y = (0.001 × AREA) – 0.080	190.6	0.867	0.842	←
	Desktop	58	Y = (0.023 × AREA) – 0.281	326.2	0.918	0.903	
curlytop knotweed	Dot	62	Y = (0.006 × DOTS) – 0.019	694.2	0.957	0.953	
	Portable	62	Y = (0.045 × AREA) – 0.012	1575.9	0.981	0.979	96-98%
	Desktop	62	Y = (0.045 × AREA) – 0.059	1067.5	0.972	0.970	

87-97%

Results
Processing Time



	Dot	Portable	Desktop
	•Longest = CYER •Shortest = LEOR	•Longest = ECWA •Shortest = ECCR	•Longest = CYER •Shortest = ECCR
Across Species:	Mean = 336 sec (5:40) R = 115 – 808 sec (13:30)	Mean = 45 sec R = 25 – 114 sec (1:54)	Mean = 15 sec R = 9 – 30 sec

What Conclusions Can Be Made?

Model Performance:

Strong Positive Relationship

- Dot grid and both scanners explained substantial variation!
  - → $R^2 > 0.87$
- All models had high predictive ability!
  - → $R^2_{pred} > 0.84$

Processing Time:

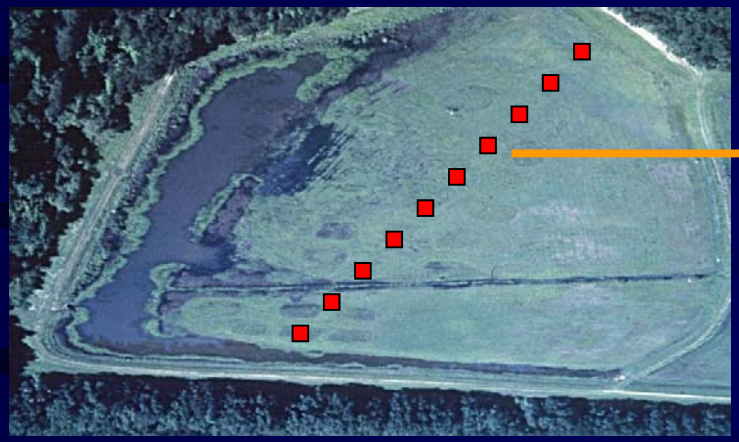
- Dot Grid took 22X longer than desktop scanner
- Portable Scanner took 3X longer than desktop scanner

15 Seconds!

Recommend Desktop Scanner Due to Efficiency

How To Use Models

Steps: 1) Establish Survey Locations



Ten 1-m^2 Plots

2) Count Stem Density

3) Collect Seed Head (s) from Plant

4) Bag and Press Seed Head

5) Scan Seed Head (or dots) Per Plant

50 cm^2

6) Average Scanned Area Per Species

$$g\ seed = -0.203 + 0.026(Area)$$

$$g\ seed = -0.203 + 0.026(50)$$

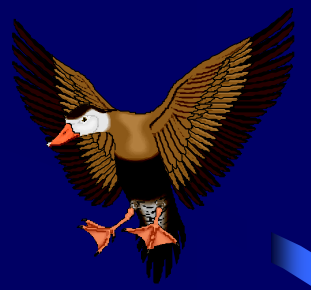
7) Predict Seed Yield Per Plant

1.1 g seed / plant

How To Use Models

Steps:

8) Average Stem Density per Species — 10 plants / m^2
9) Multiply Seed Prediction x Stem Density — 11 g / m^2
10) Sum Seed Yield Across Species — 11 g / m^2 (one species)
11) Convert g/m^2 to kg/ha — 110 kg / ha (succession??)
12) Multiply by Wetland Area — 10 ha = 1110 kg
13) Calculate DEDs



$$DED = \frac{1110\ kg \times 2500\ kcal/kg}{292\ kcal/day} = 9503\ DEDs \div 110\ days$$

Excel® Spreadsheet
- Scanned Area
- Stem Density

86 Ducks per Day for 110 Days

Wetlands Program
University of Tennessee-Knoxville

We'll Process Seed Heads for You!

- $20 / m^2 plot if seed heads are pressed
- $25 / m^2 plot if seed heads are <u>not</u> pressed
- $800 per plant species to develop new models

Fees go to UT Wildlife Students!

Steps:

1) Collect One Random Seed Head per Species per Plot
2) Count Stem Density per Species per Plot

n = 10 plots

3) Press Seed Heads for One Week or Mail Directly to UT

Products per Impoundment:

- Seed Production and DED per Plant Species
- Total Seed Production and Total DED

Acknowledgments

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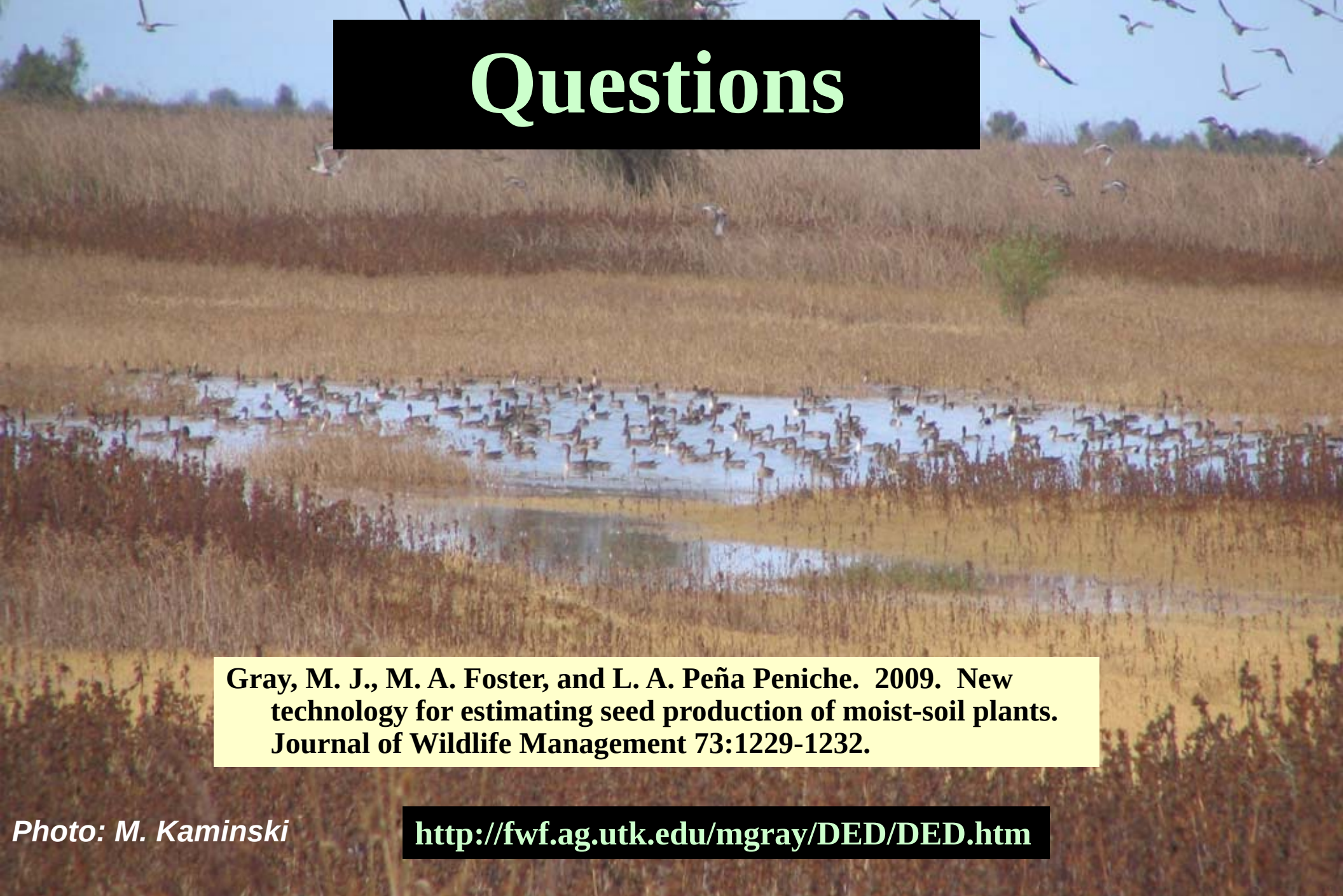
- UT Institute of Agriculture
- U.S. Fish and Wildlife Service
- Tennessee Wildlife Resources Agency

Questions



Gray, M. J., M. A. Foster, and L. A. Peña Peniche. 2009. New technology for estimating seed production of moist-soil plants. Journal of Wildlife Management 73:1229-1232.

Photo: M. Kaminski

http://fwf.ag.utk.edu/mgray/DED/DED.htm