# Cellular Seismology in the Central and Eastern United States?

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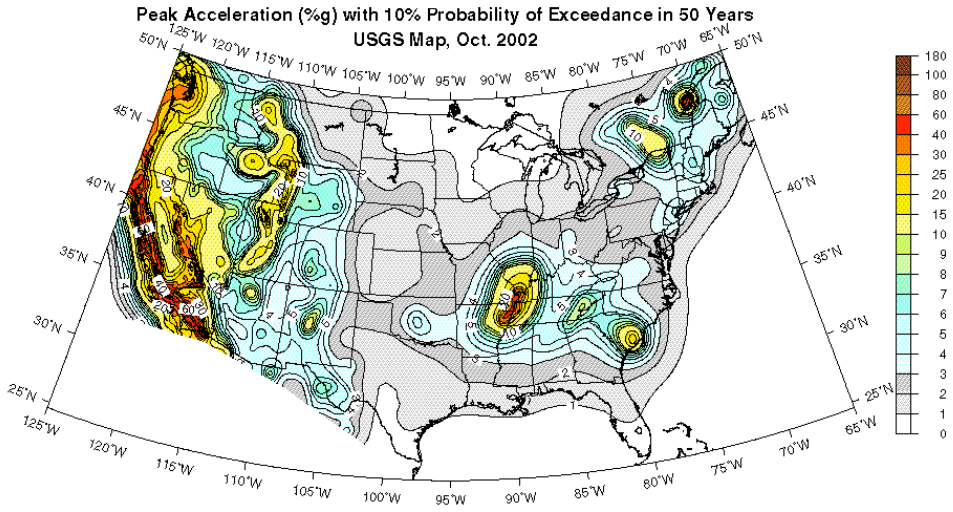



USGS National Seismic Hazard Maps

Past Seismicity→ Future Earthquakes

**Questions:**

**(1) Is the "tendency for future earthquakes to occur near past earthquakes" a real, measurable, physical phenomenon?**

**(2) Do we have samples that are representative of this phenomenon?**

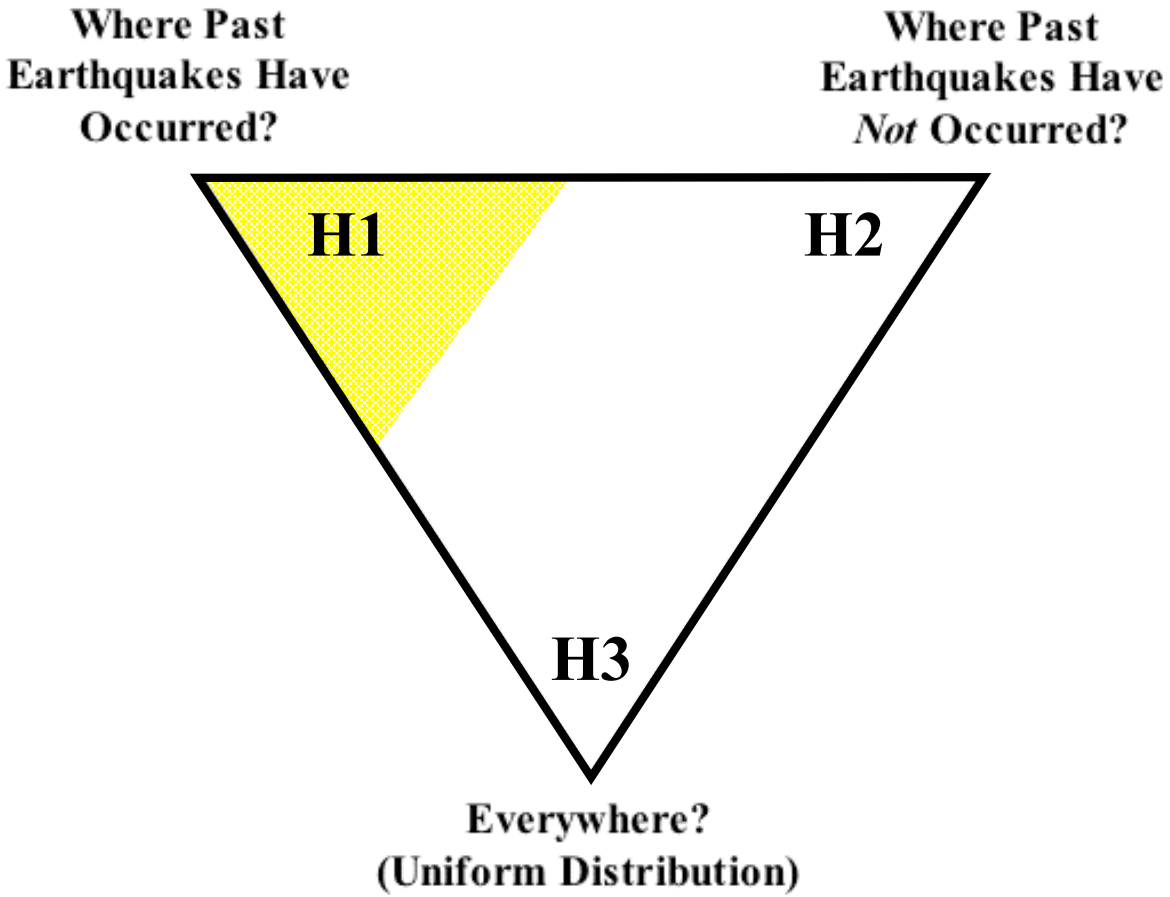
**(3) Can we measure it?**

**"When you can measure something and express it in numbers, you know something about it."**

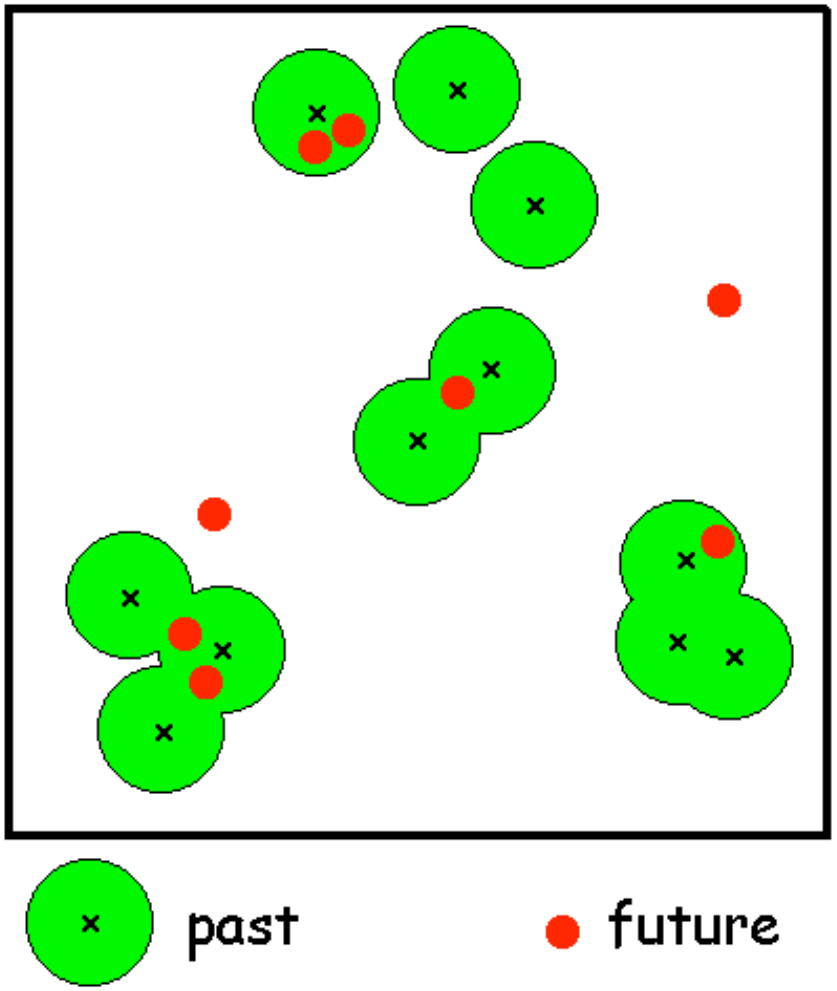
**- Lord Kelvin**

**Relative to the Spatial Distribution of Past Earthquakes,**

# Future Large Earthquakes Occur:



"Cellular Seismology"



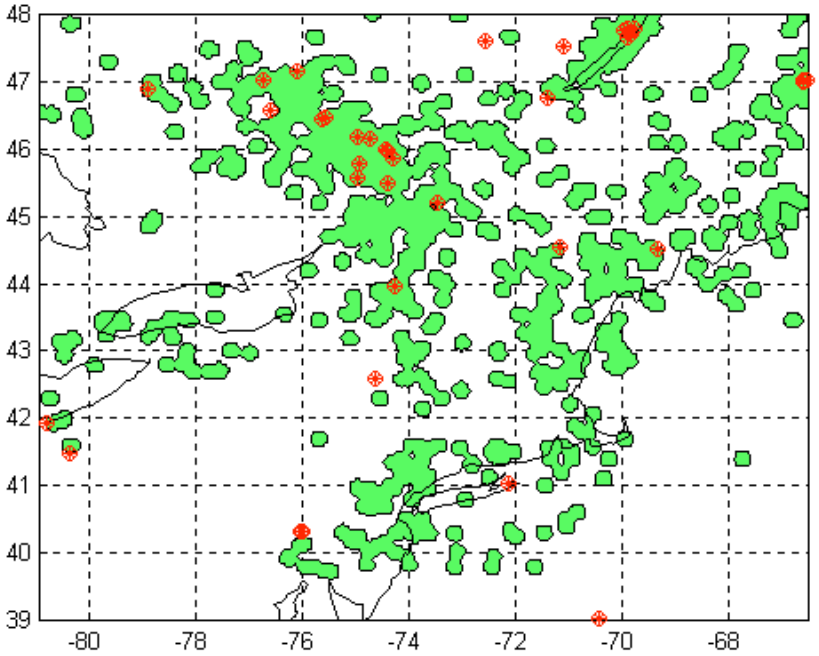

Choose a radius such that circles fill P percentage of map area.

$\hat{\rho}$ = 6/8 = 75% = sample of binomial random variable, $\rho$.

$\rho$ = Probability("success")

success = red circle occurs within one of the green circles.

## Northeastern United States

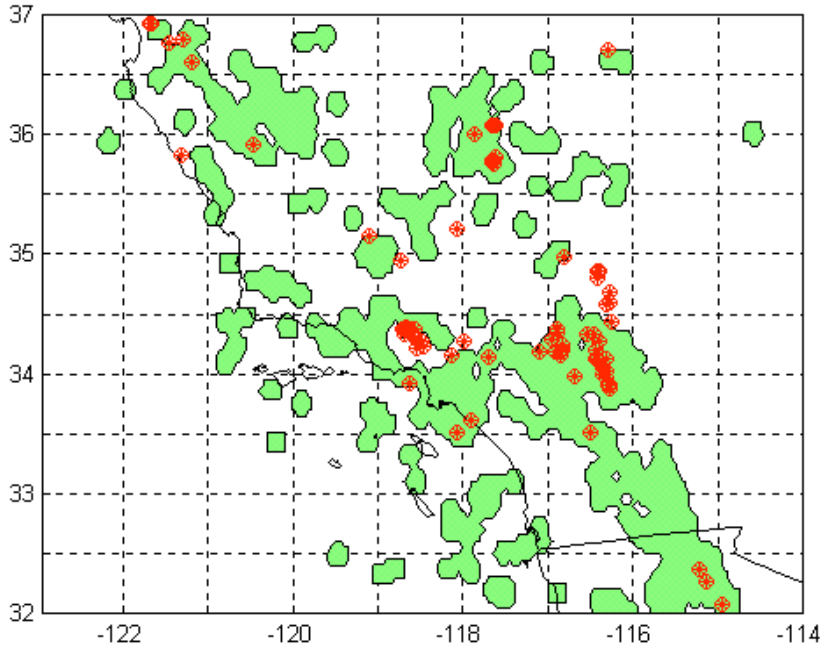



**M ≥ 2.0 (1975-1987)**
**M ≥ 4.0 (1988-2001)**

78% Hits

33% Map Area

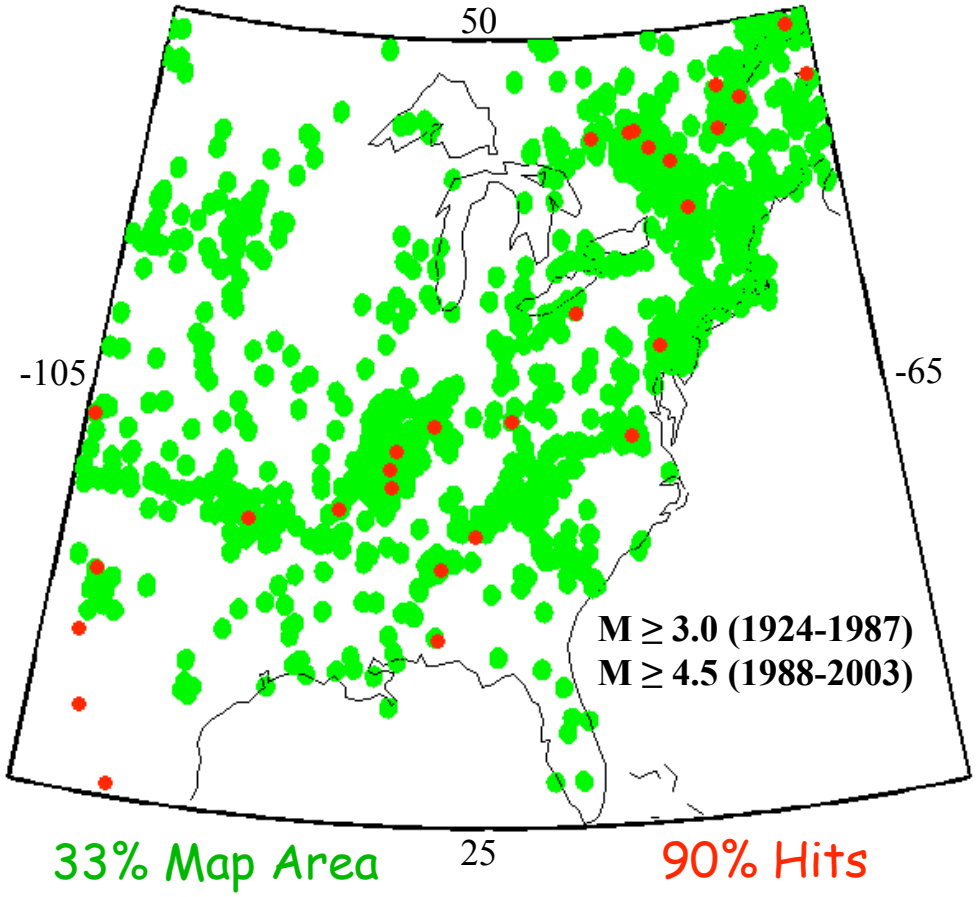
## Southern California

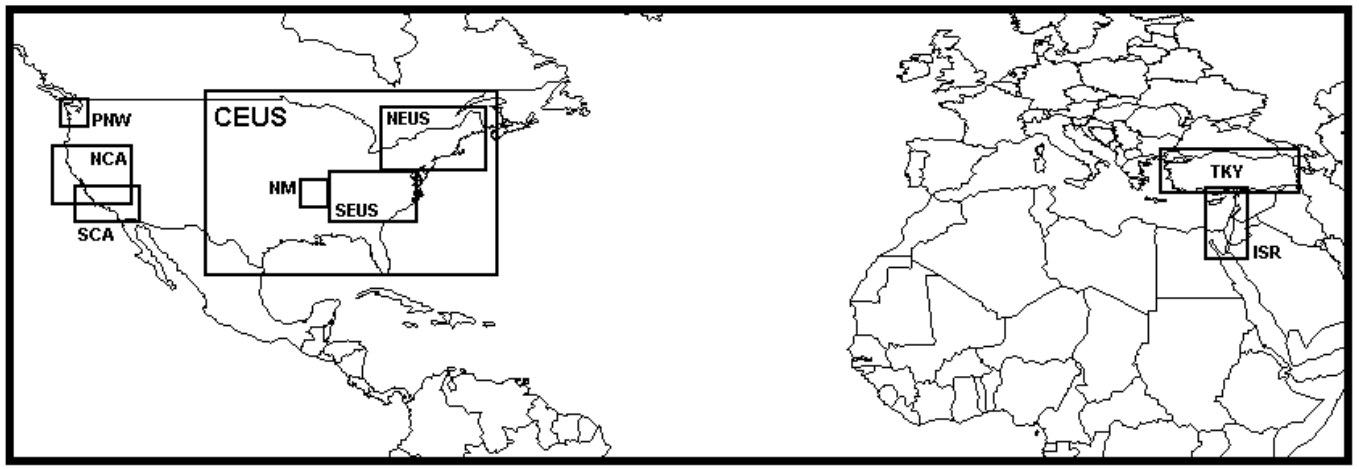



**M ≥ 3.0 (1984-1987)**
**M ≥ 5.0 (1988-2001)**

79% Hits

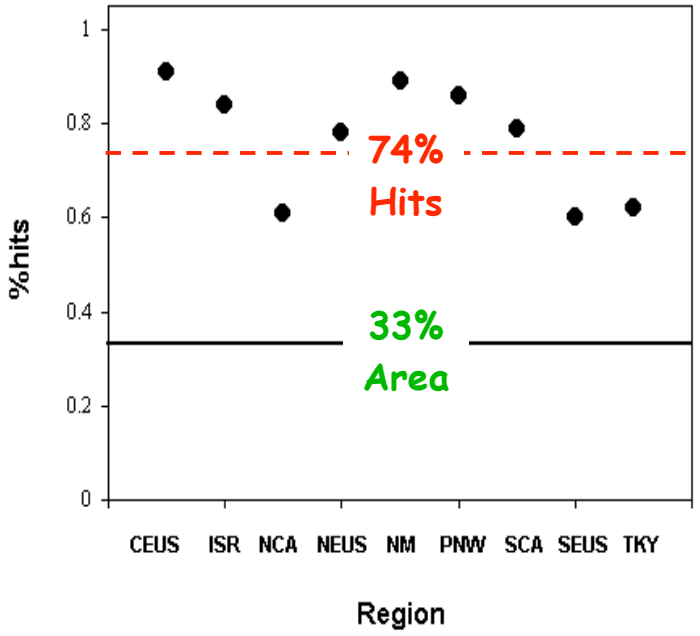
## Central and Eastern United States



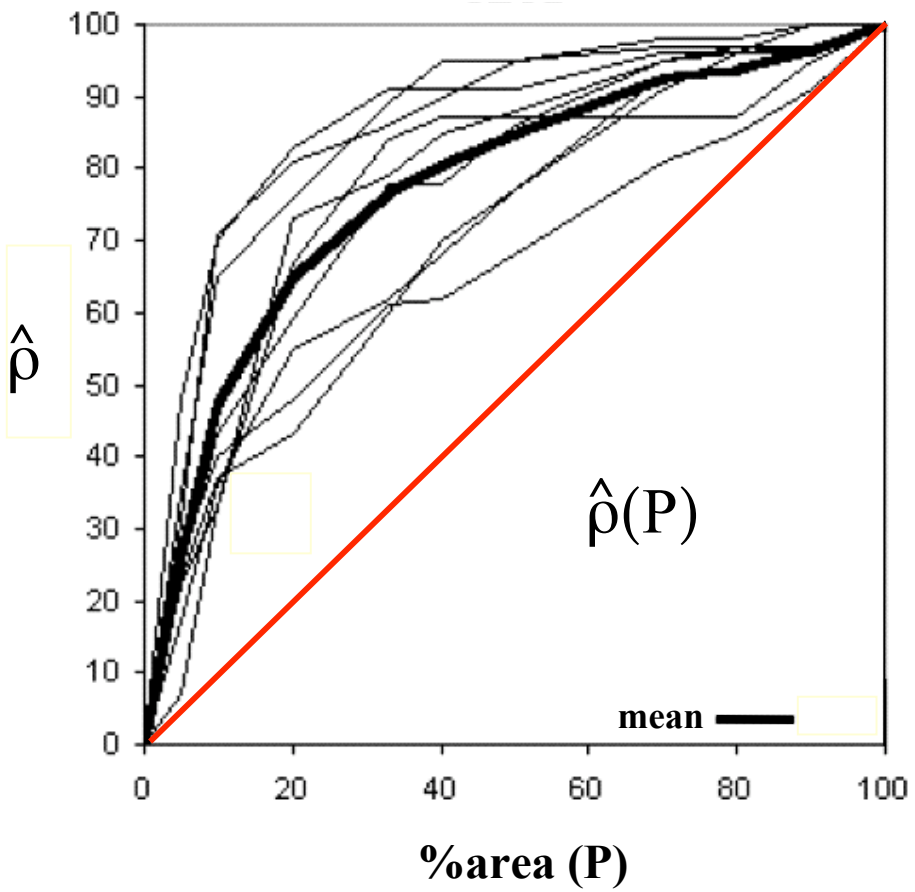



## Regions Studied

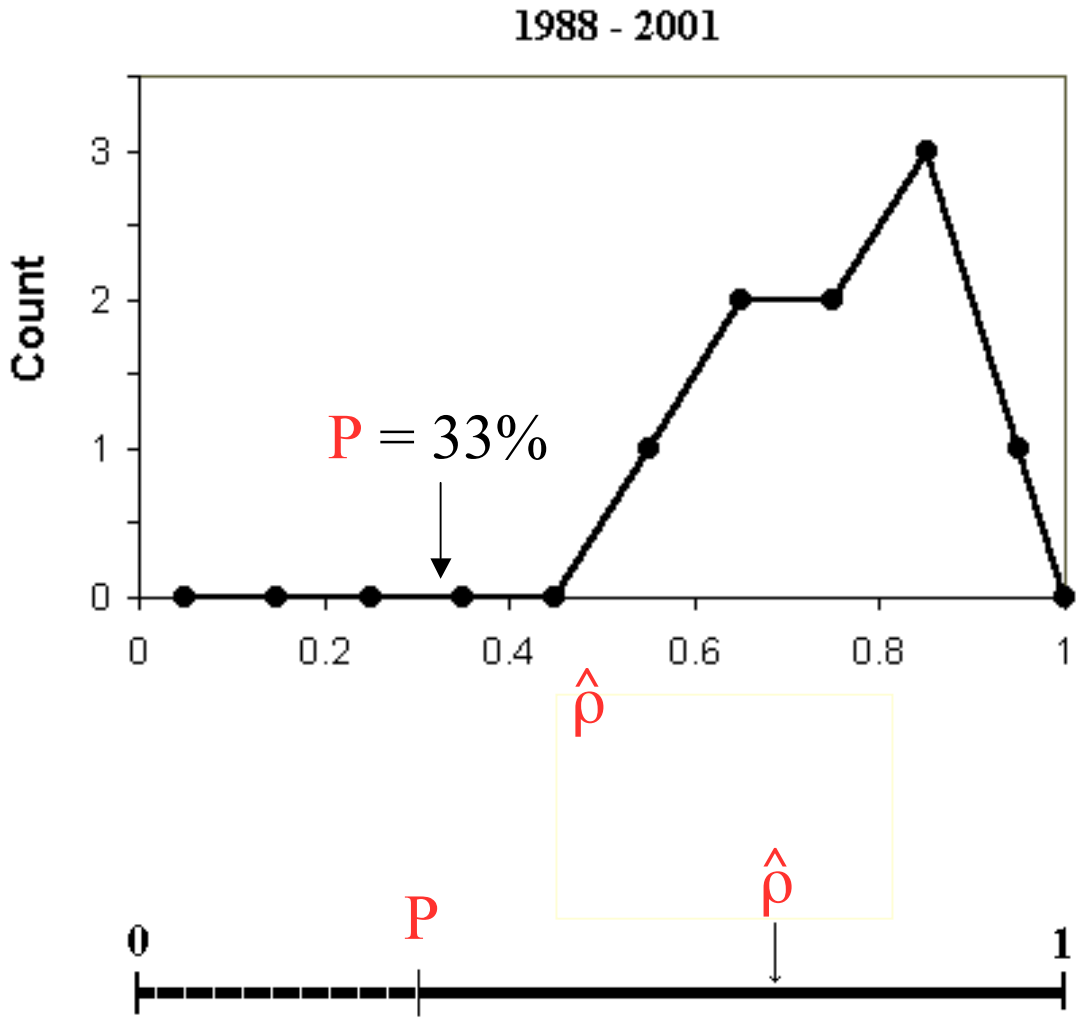
NEUS = Northeastern US
SEUS = Southeastern US
NM = New Madrid
CEUS = Central and Eastern US
SCA = Southern California
NCA = Northern California
PNW = Pacific Northwest
ISR = Israel
TKY = Turkey




## Results (1988-2001)


100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
ρ̂
ρ̂(P)
mean
%area (P)

# What is the distribution of $\hat{\rho}$, for a given P?

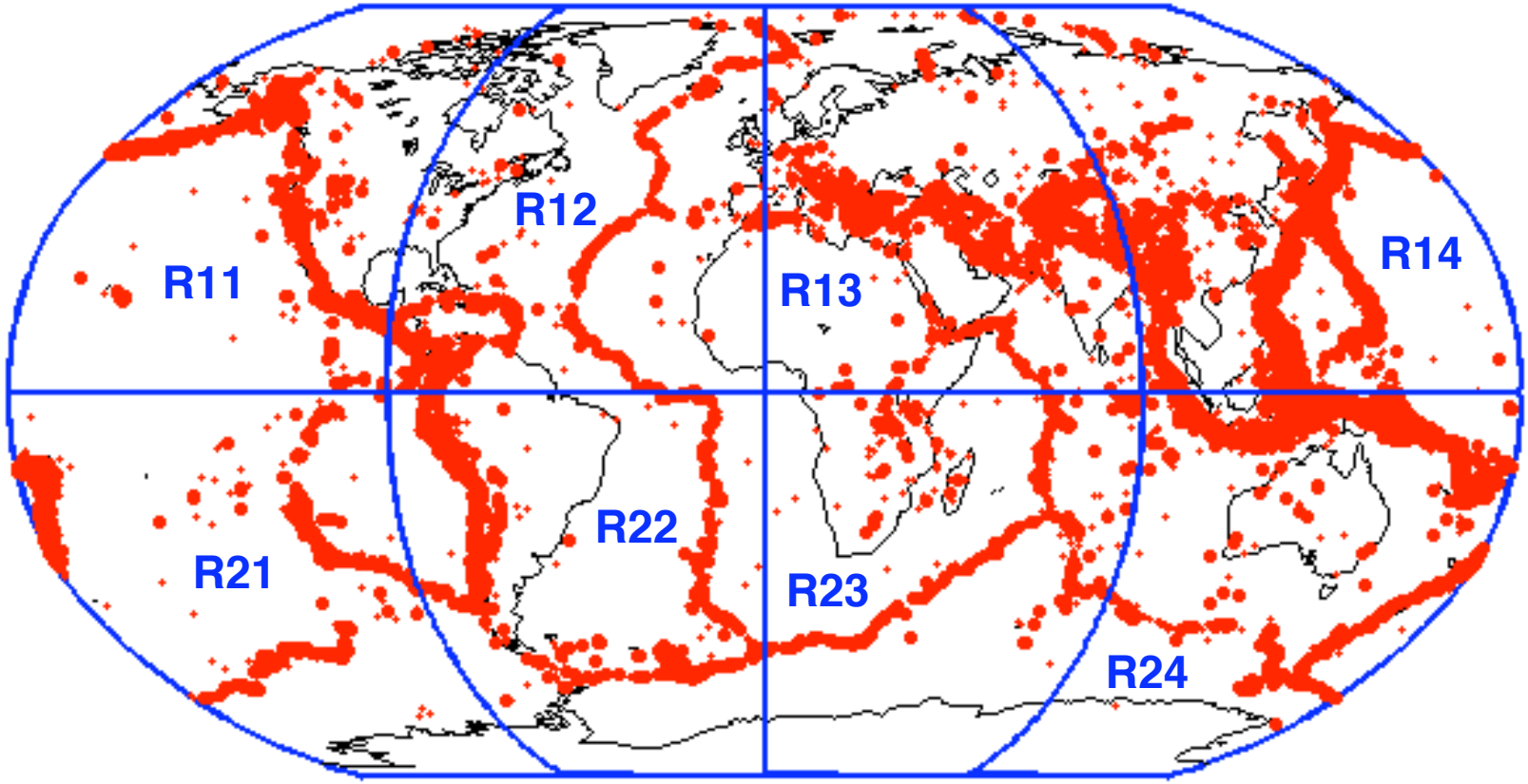



**What is the best estimate of $\rho$, for a given P?**

**What is the 95% confidence interval for $\rho$, for a given P?**

From Kafka (SRL, 2002)

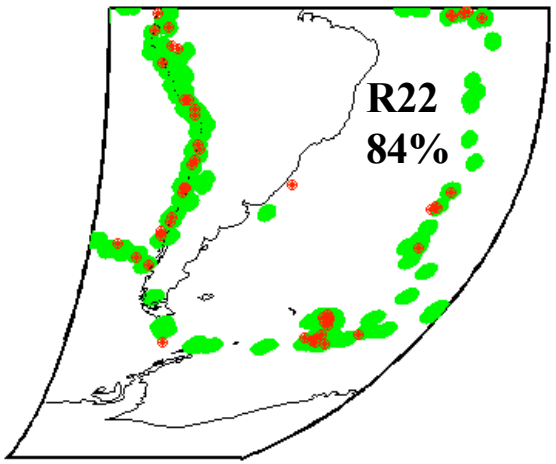
# NEIC 1973-2002

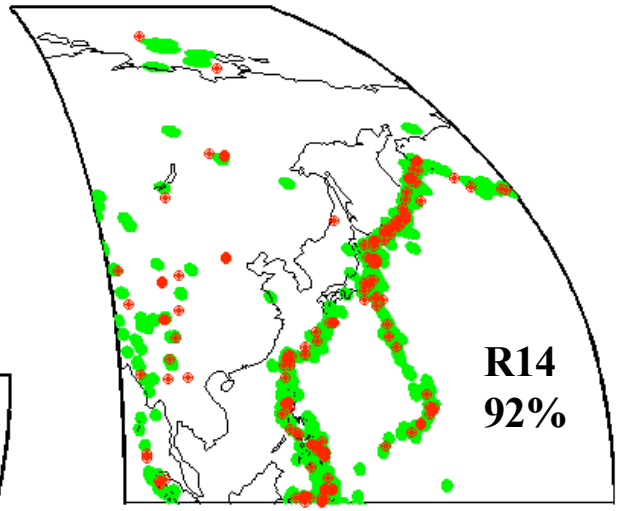


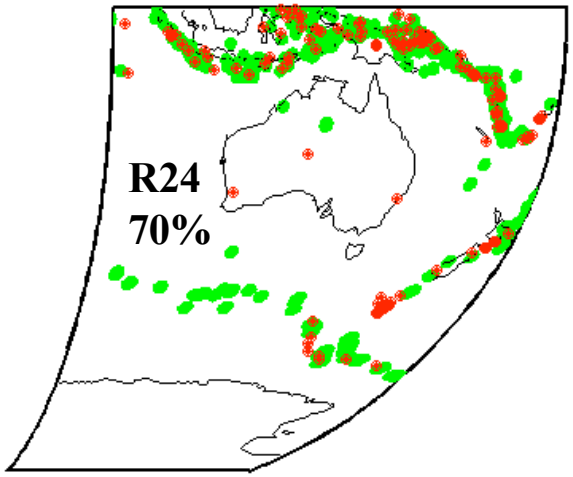

**Magnitude ≥ 5.0**

87-88 (M5.0+)
89-90 (M5.5+)

P = 10% Area




Can apply Cellular Seismology method to many:

two-year ("past")

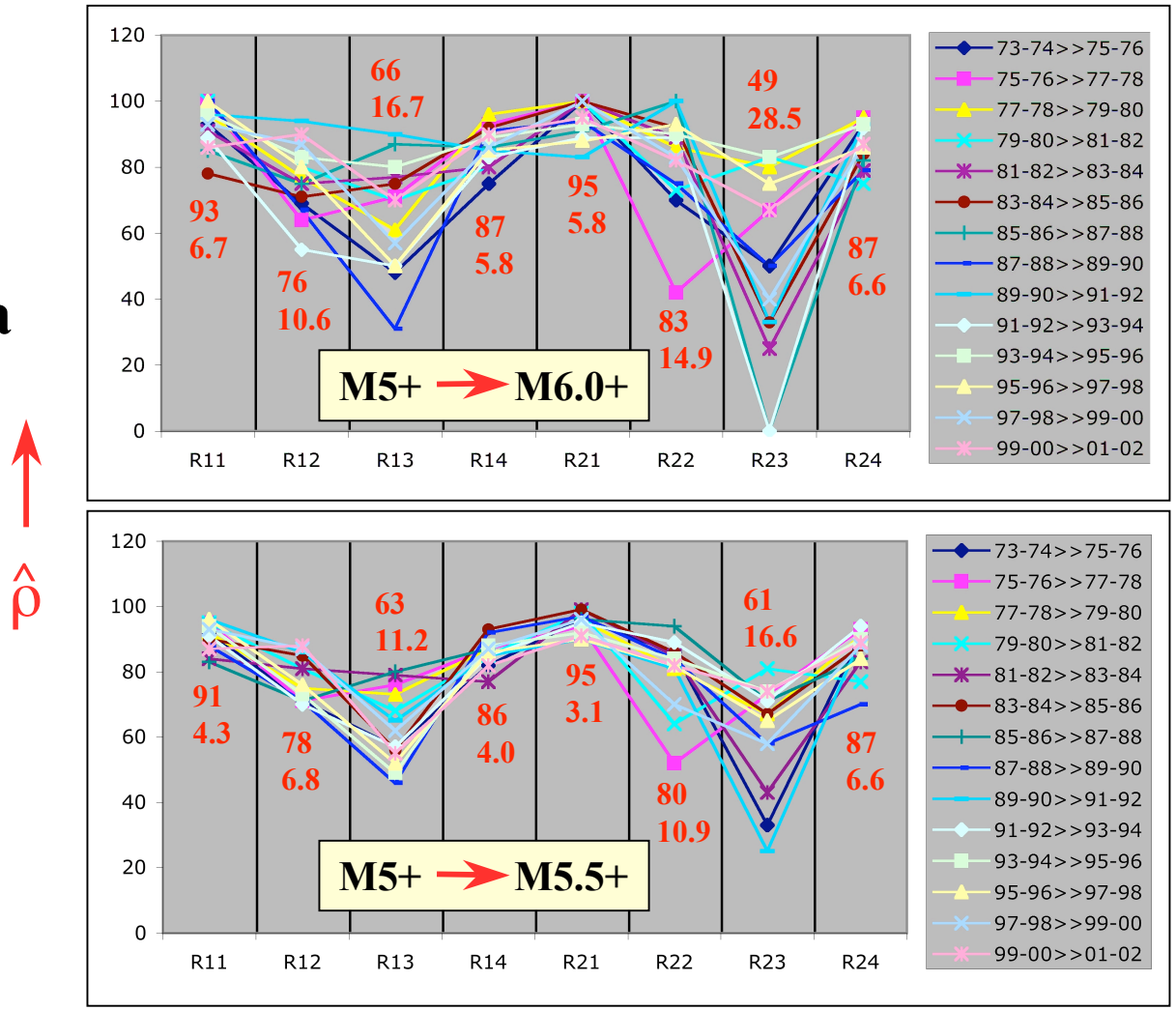
⬇

two-year ("future")

sub-catalogs of NEIC data,

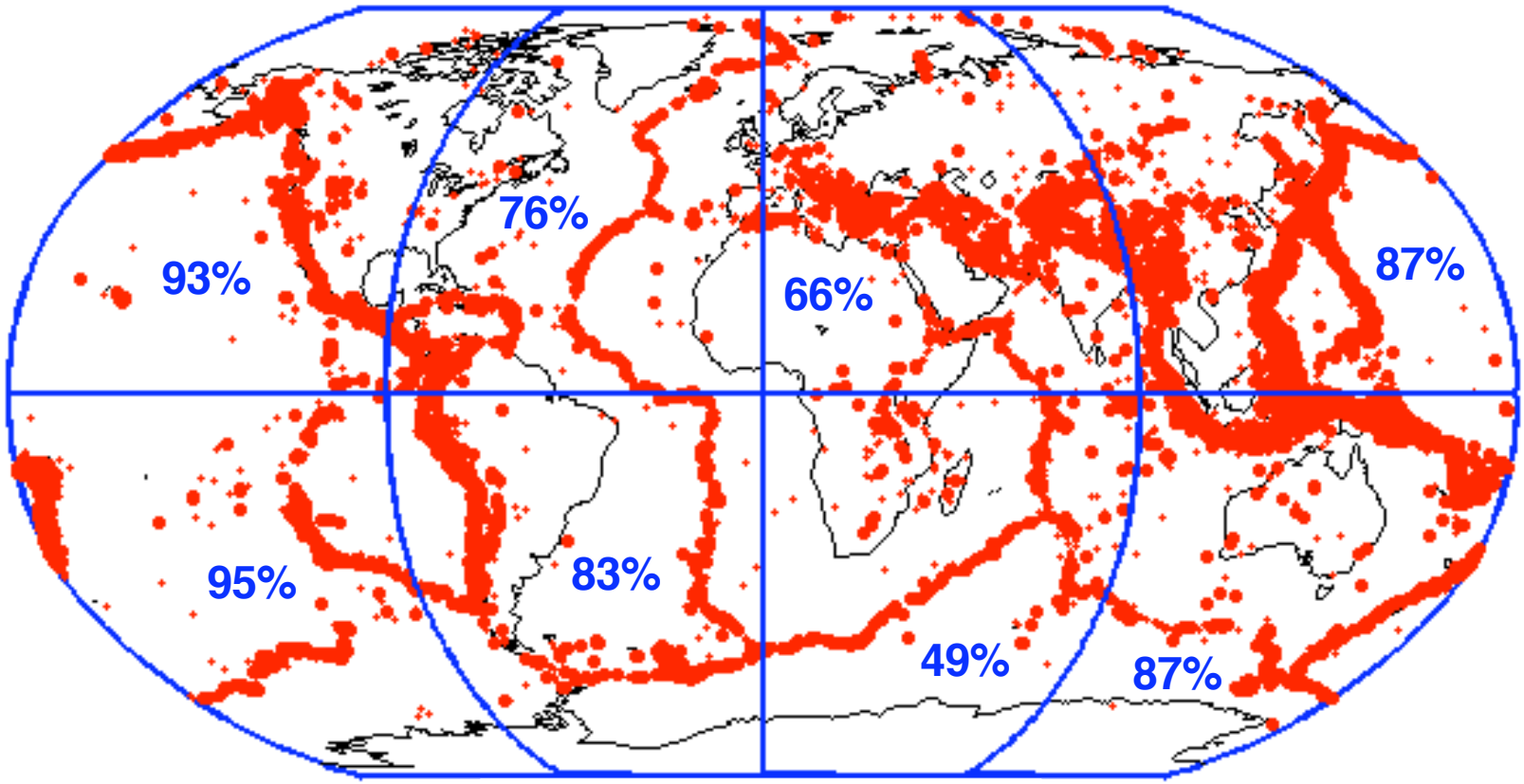
and test hypotheses systematically.

**10%**
**Map Area**

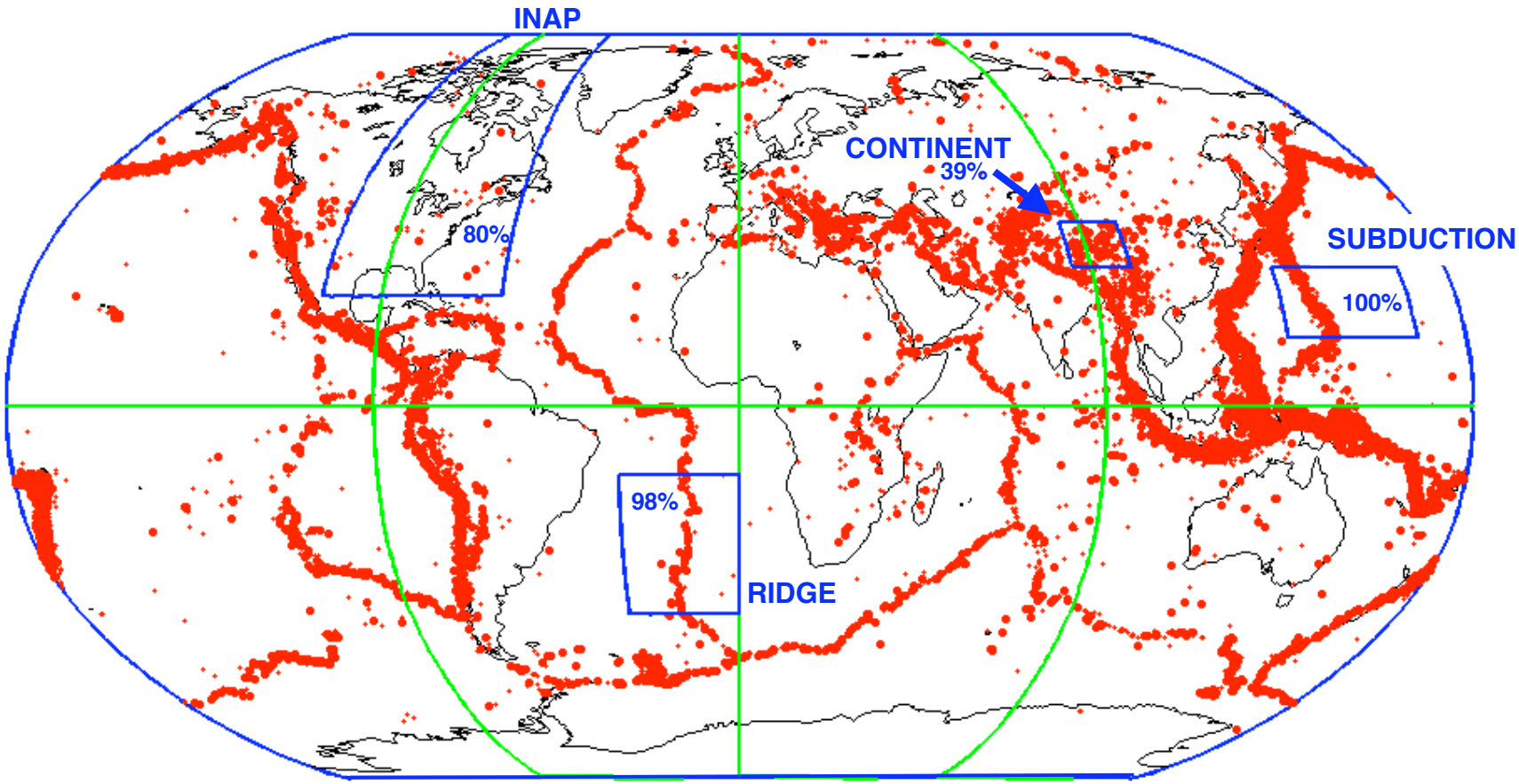



$\hat{\rho}$

**Region**

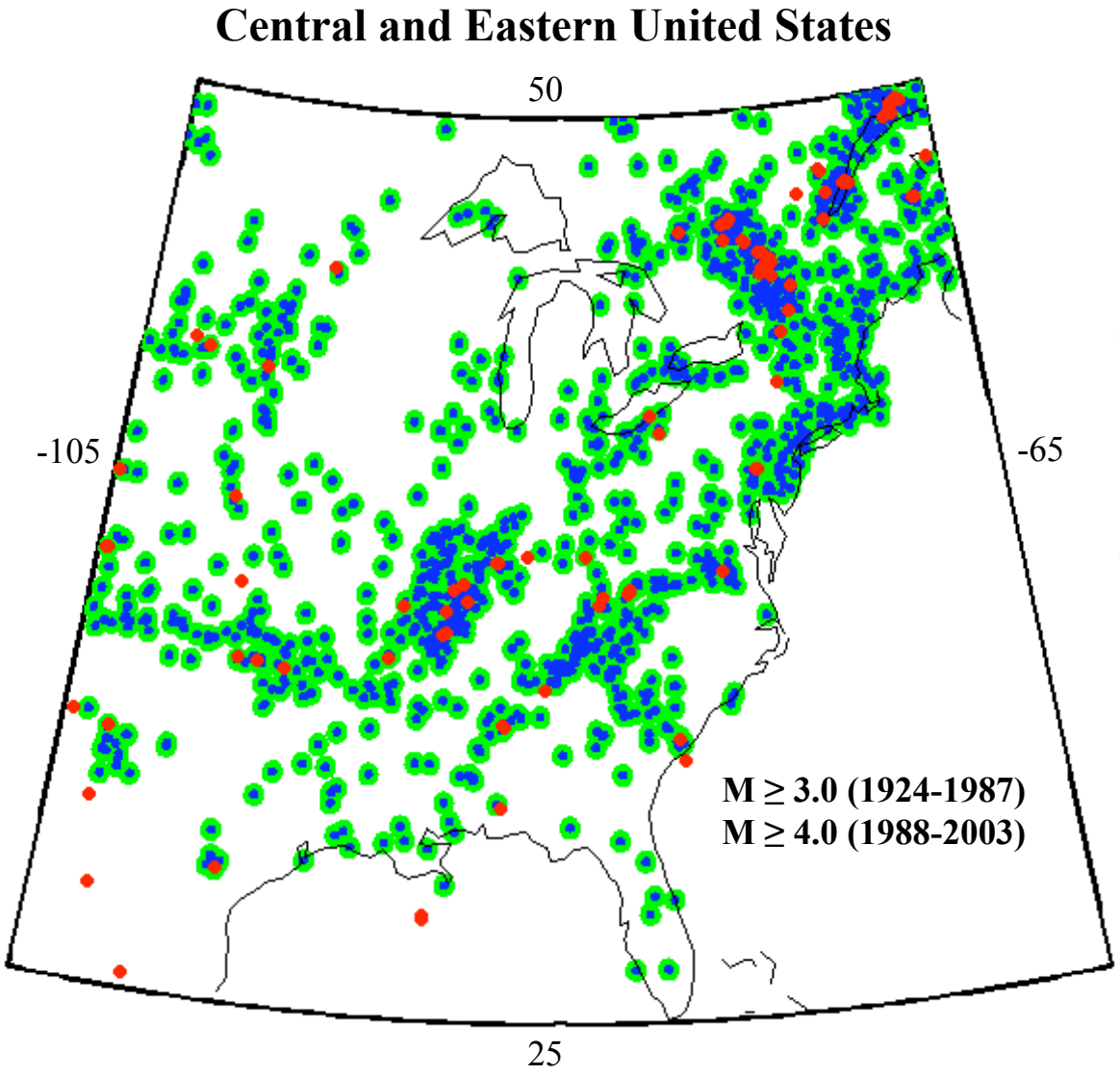



%Hits for 10% Map Area




## %Hits for 33% Map Area

**INTERIOR OF NORTH AMERICAN PLATE (INAP): 80%**
**CONTINENT: 39%  RIDGE: 98%  SUBDUCTION: 100%**




**green zones = 36 km radius = 33% map area**
**blue zones = 14 km radius = 10% map area**

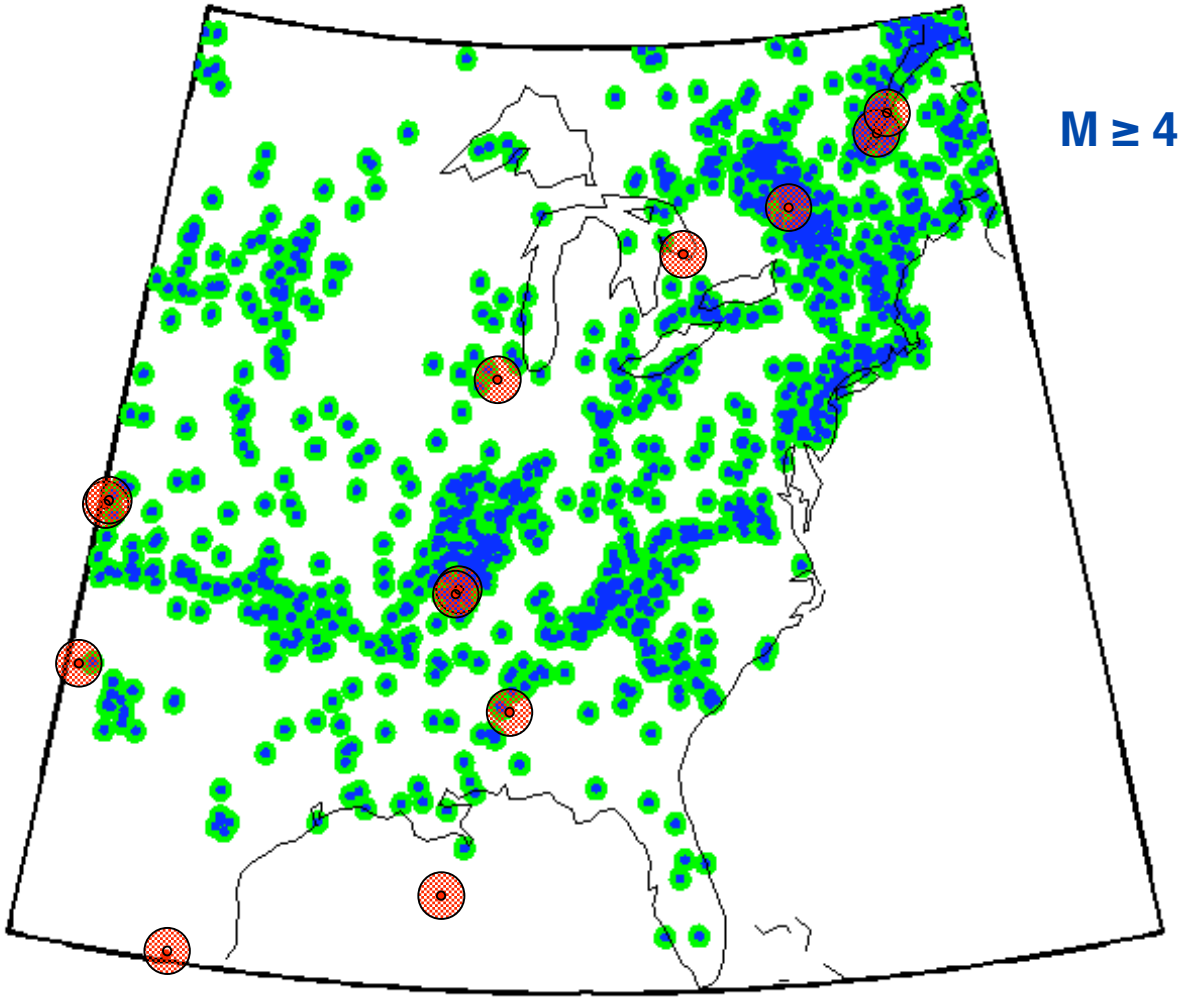
Future large earthquakes in the CEUS have about 86% probability of occurring within 36 km of past earthquakes, and about 60% probability of occurring within 14 km of past earthquakes.

- Kafka (2005)

$$\hat{\rho}(0.33)=0.86$$
$$0.79 \le \rho(0.33) \le 0.93$$

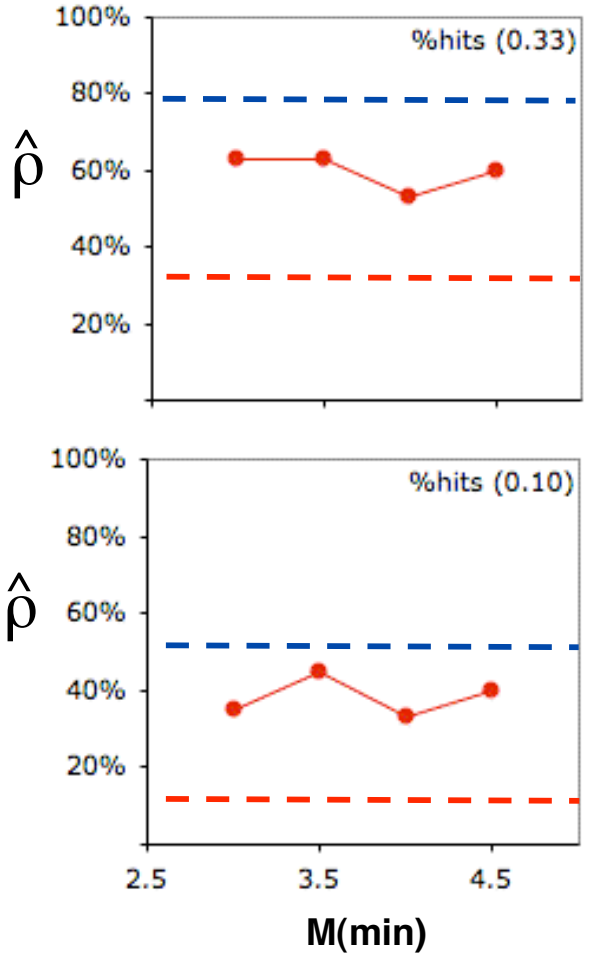
$$\hat{\rho}(0.10)=0.60$$
$$0.50 \le \rho(0.10) \le 0.70$$

## Central and Eastern United States



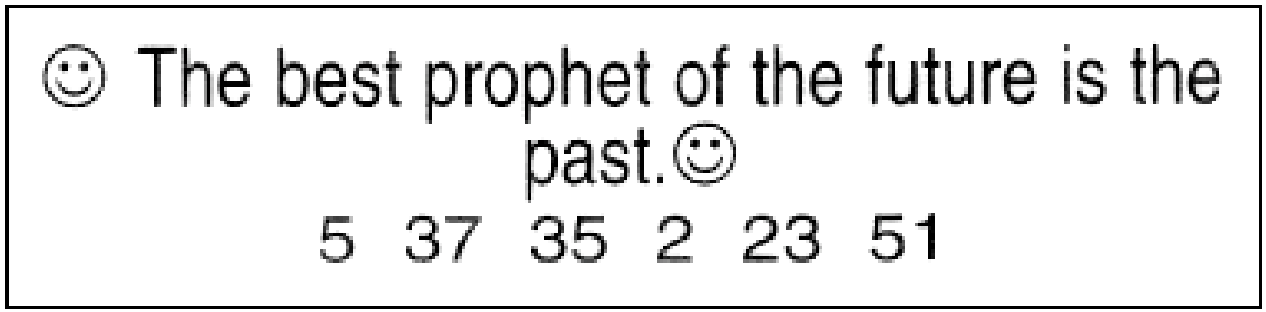
**M ≥ 3.0 (1924-1987)**

**M ≥ 4.0 (January 2004 - April 2006)**



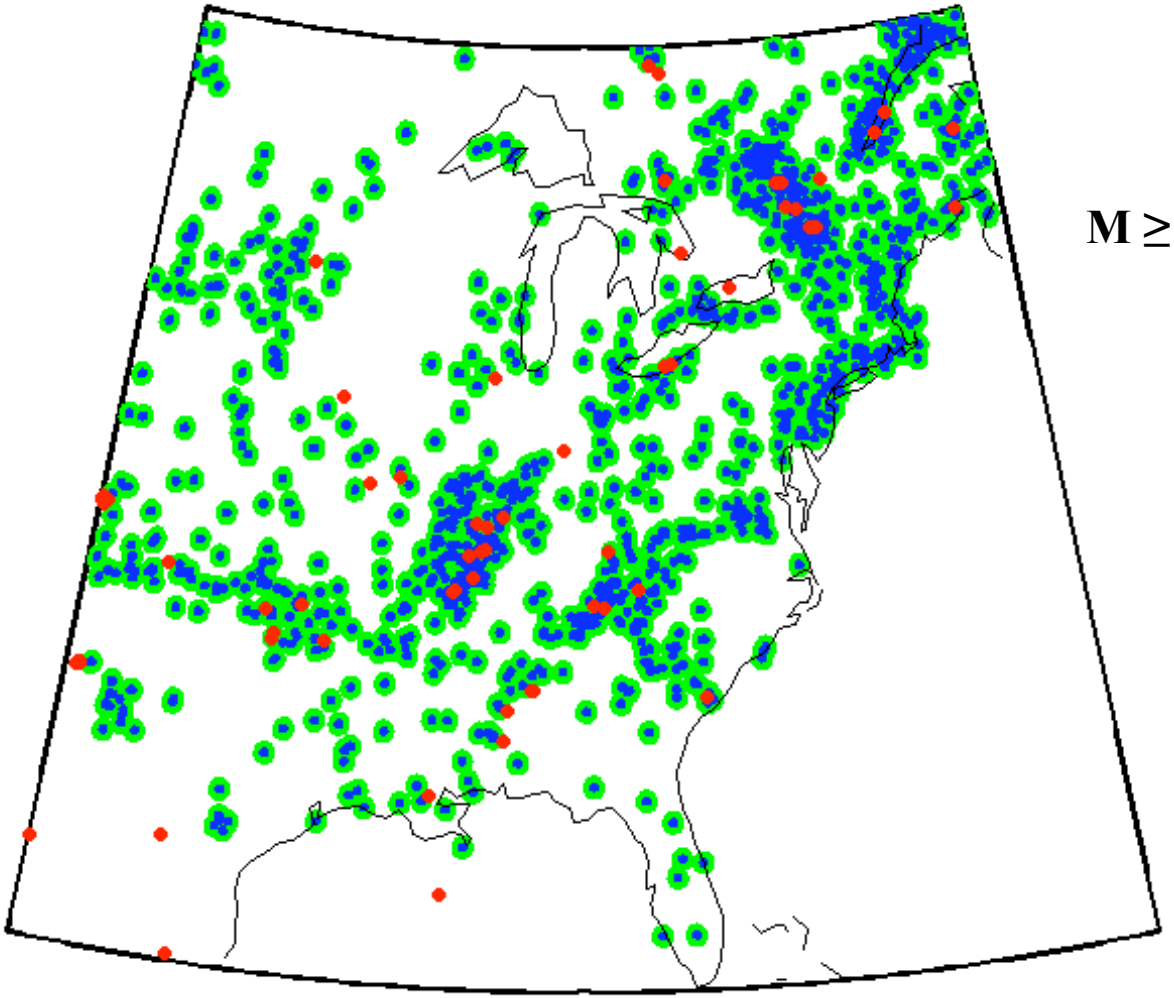

**green zones = 33% map area → 53% hits**

**blue zones = 10% map area → 33% hits**




**Fortune cookie**

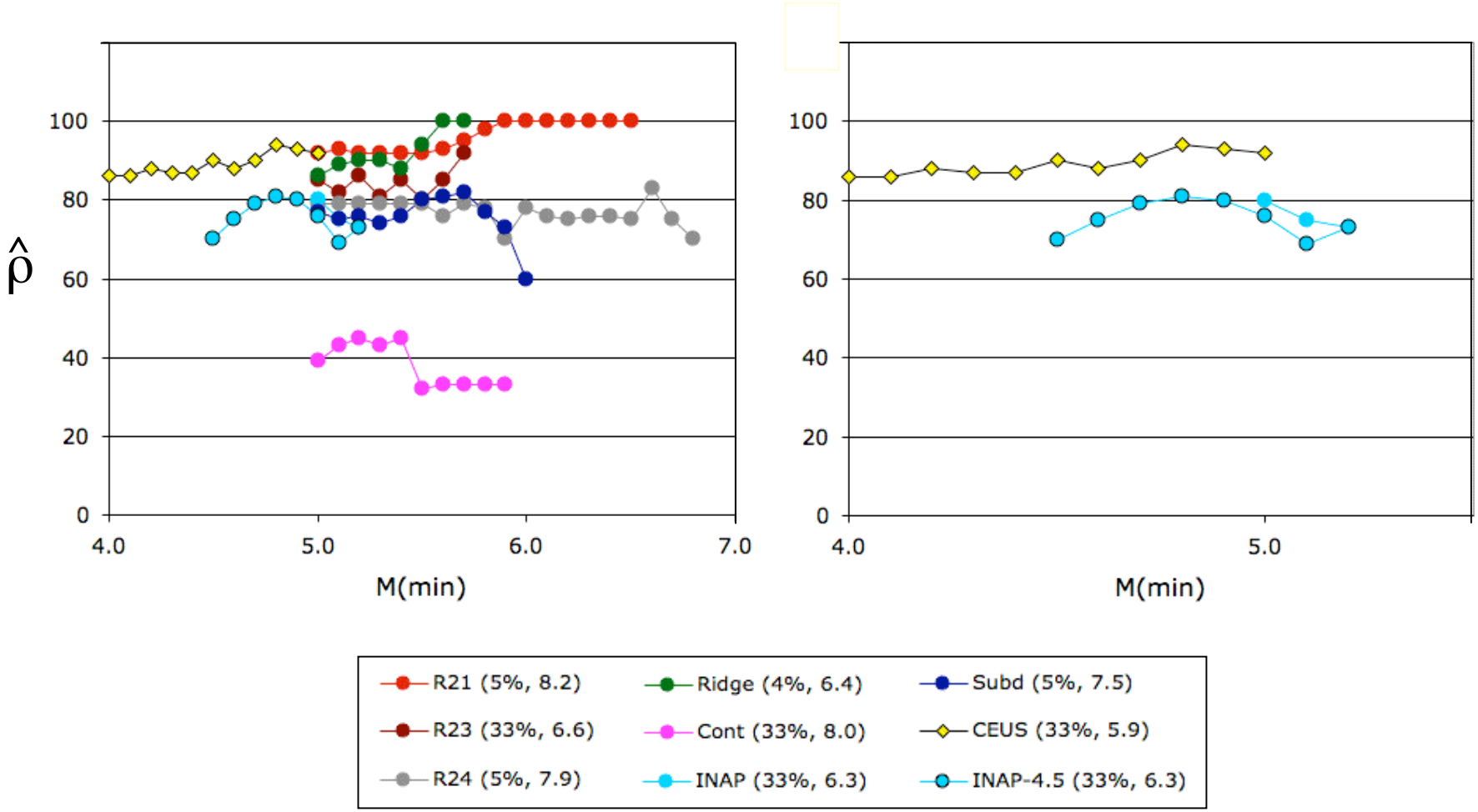
## Central and Eastern United States

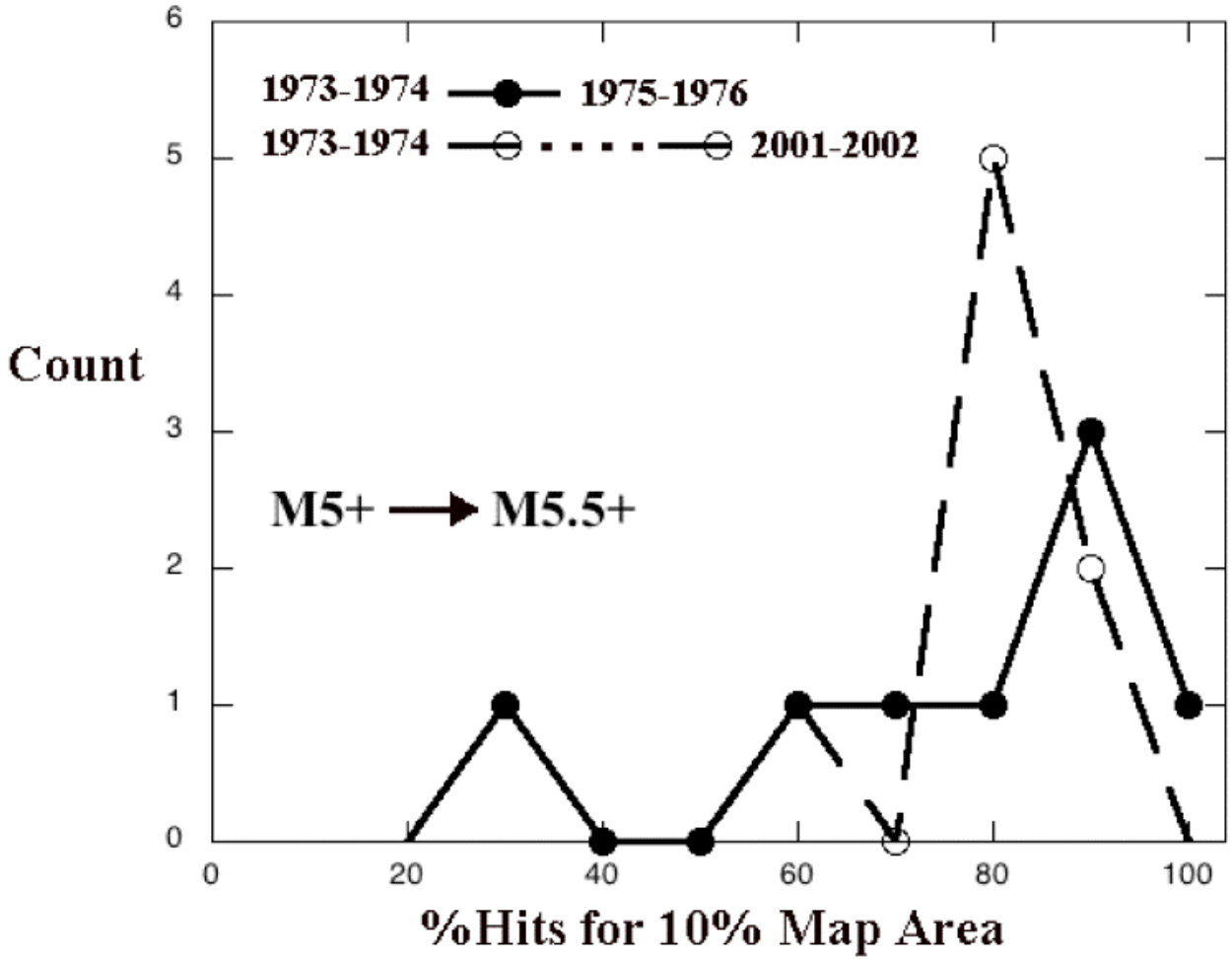


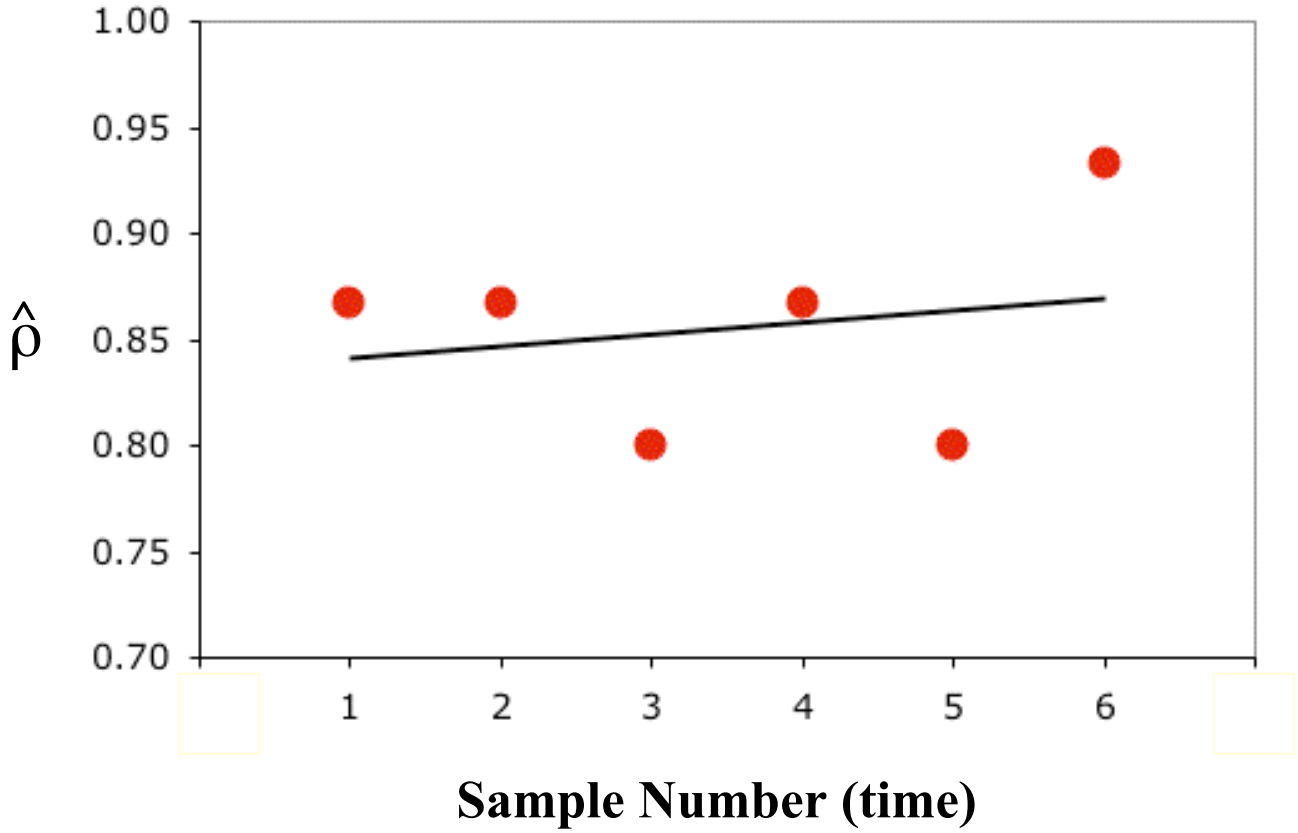
**M ≥ 3.0 (1924-1987)**

**M ≥ 3.0 (January 2004 - April 2006)**

**green zones = 33% map area → 63% hits**
**blue zones = 10% map area → 35% hits**


$\hat{\rho}$
100
80
60
40
20
0
4.0
5.0
6.0
7.0
M(min)
100
80
60
40
20
0
4.0
5.0
M(min)
R21 (5%, 8.2)
Ridge (4%, 6.4)
Subd (5%, 7.5)
R23 (33%, 6.6)
Cont (33%, 8.0)
CEUS (33%, 5.9)
R24 (5%, 7.9)
INAP (33%, 6.3)
INAP-4.5 (33%, 6.3)


1973-1974 1975-1976
1973-1974 2001-2002
M5+ → M5.5+
Count
%Hits for 10% Map Area
0
1
2
3
4
5
6
0
20
40
60
80
100


1.00
0.95
0.90
0.85
0.80
0.75
0.70
ρ̂
1
2
3
4
5
6
Sample Number (time)