The Impact of NWS Weather Forecast Office Culture on Tornado Warning Performance

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Office of Science and Technology
National Weather Service

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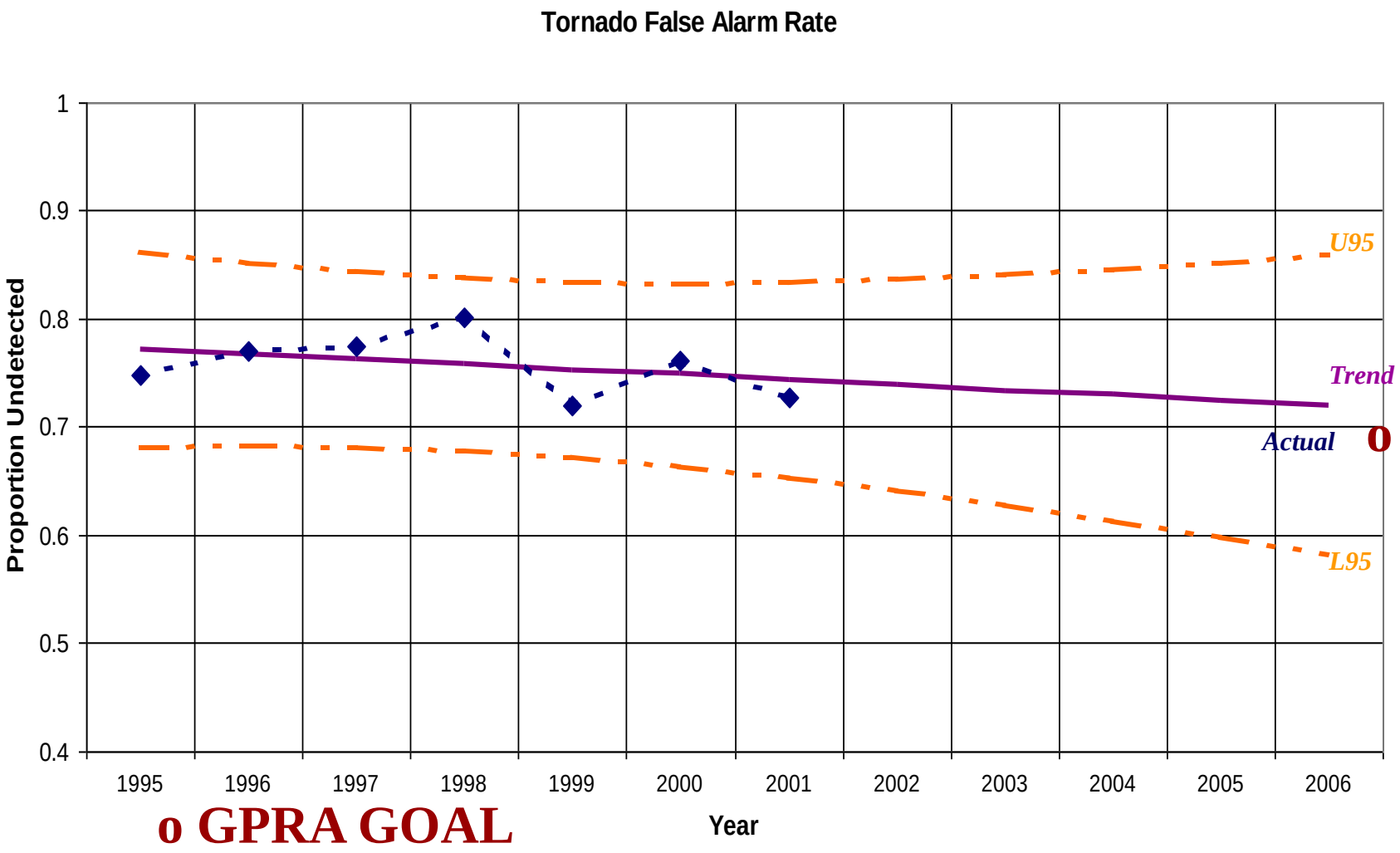
Acknowledgements:
Shaun Del Duco,
Lou Mischkind,
Brent MacAloney
and the OCWWS
Stats-on-Demand Team



Descriptive Statistics:

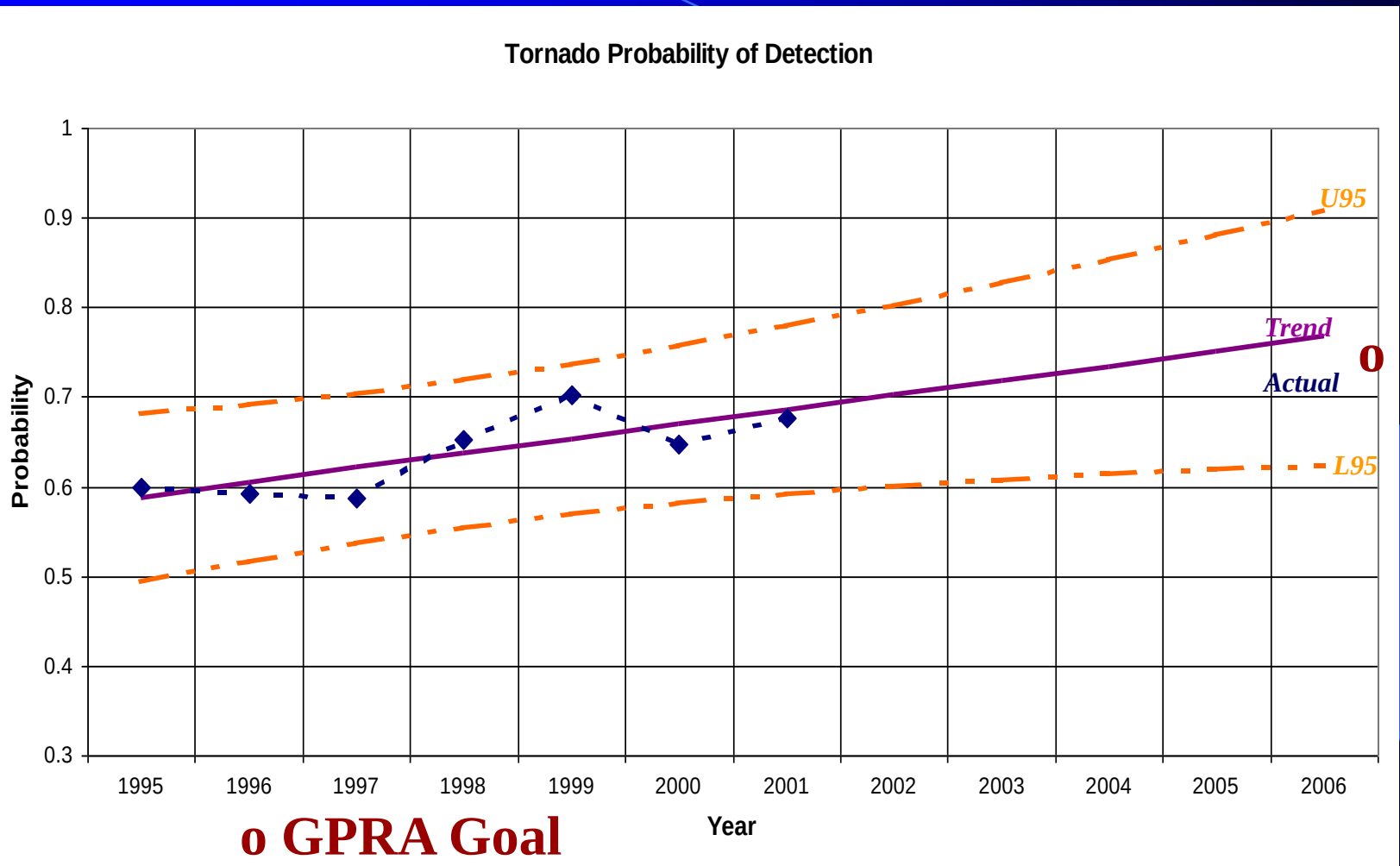
Constant = 10.0956

Coefficient = -0.0047

Rsqr = 0.127

T-value for slope = -0.85

2-tailed t-test 95% CI w/ 5 degrees of freedom = 2.57



Descriptive Statistics:

Constant = -31.8362

Coefficient = .0163

Rsqr = 0.623

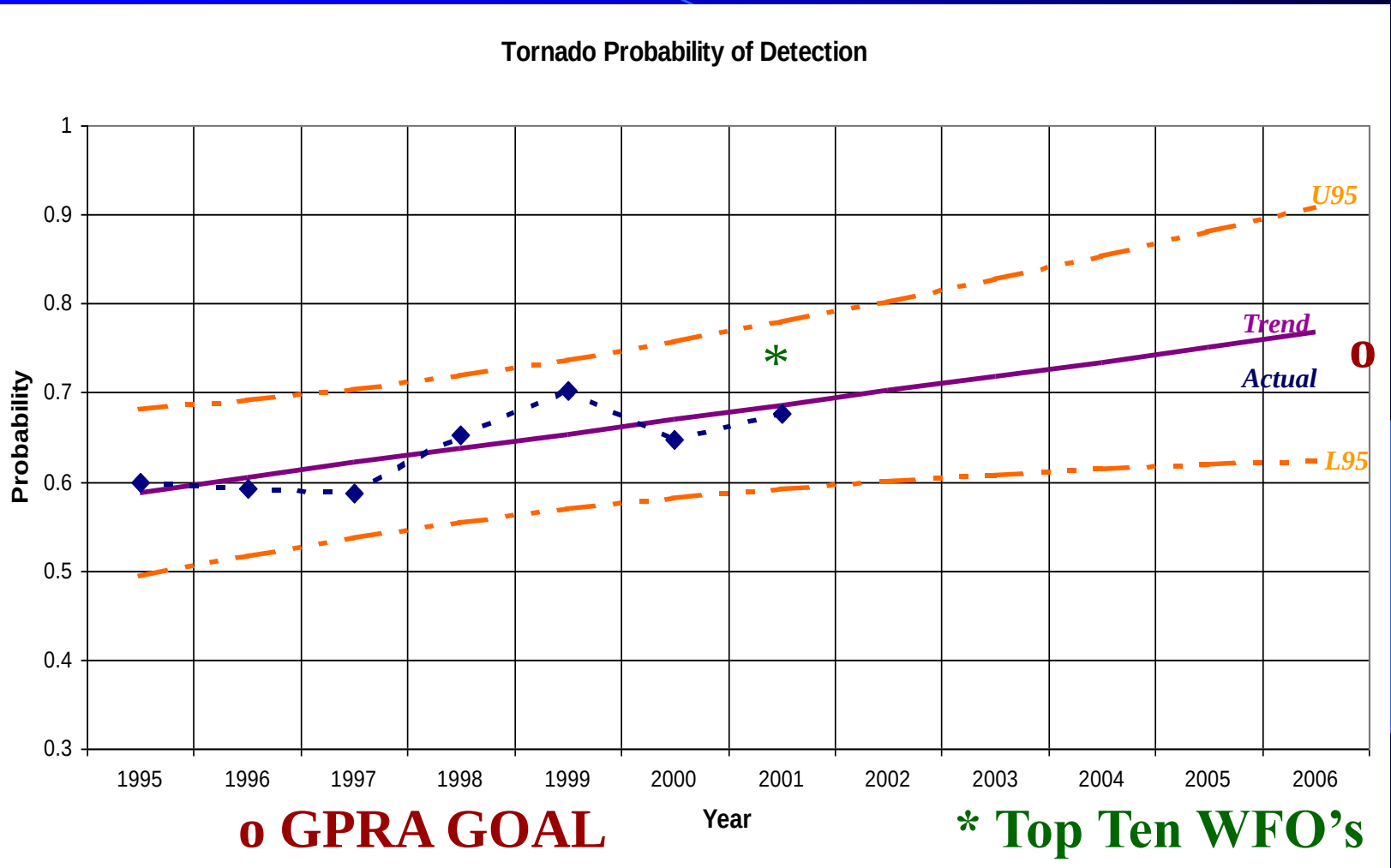
T-value for slope = 2.87

2-tailed t-test 95% CI w/ 5 degrees of freedom = 2.57

Questions asked by National Weather Service Management

- How do we improve our tornado warning verification statistics?
- How will we meet our goals for tornado warnings?
- What do we invest our resources in?

Examine the Top Ten Offices



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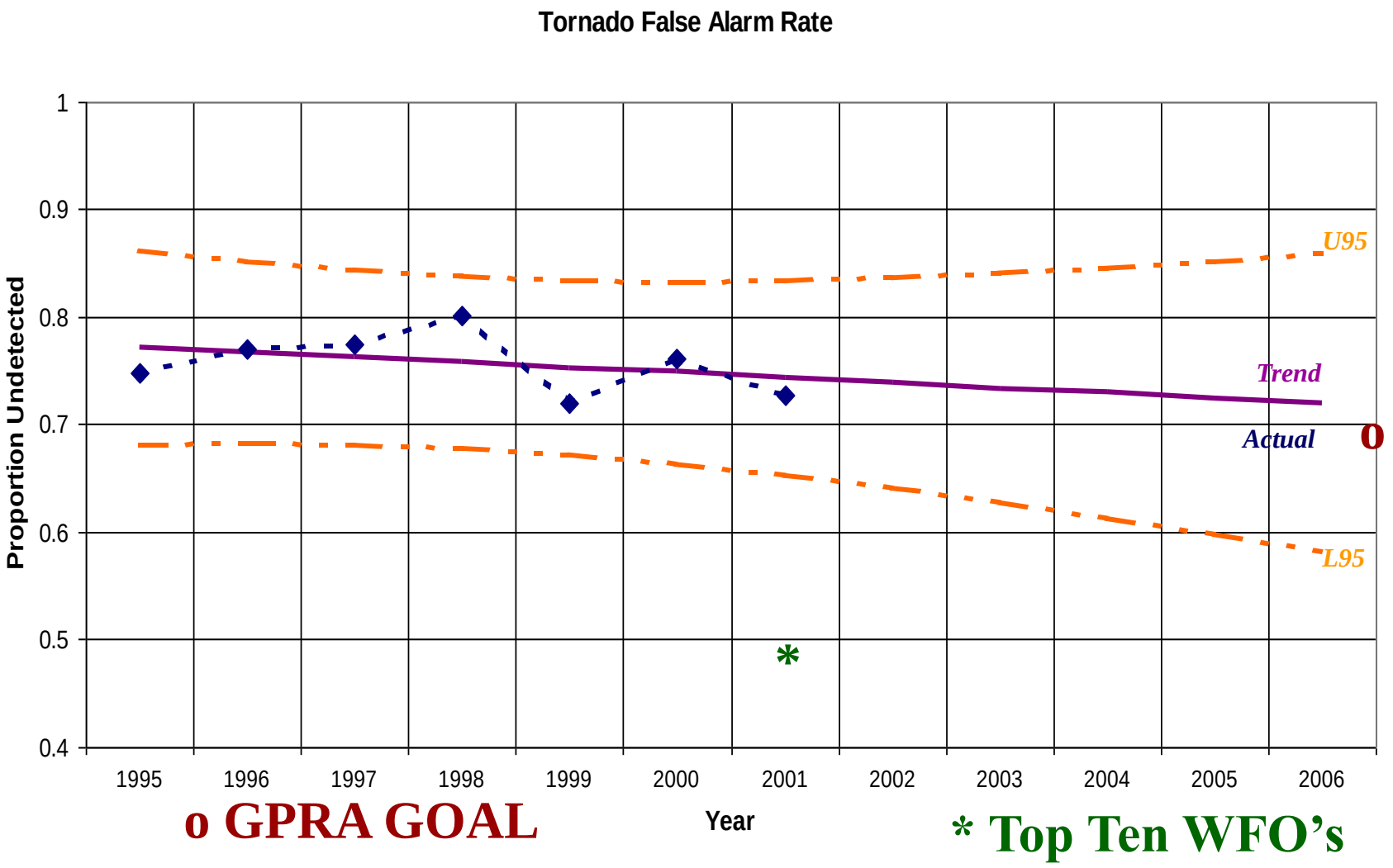

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T-value for slope = -0.85

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Why are the Top Ten Offices doing so well?

- Better Science and Technology?
- Easier Verification?
- Easier Storms?
- More Practice?
- WFO Culture??????

Idioculture – culture in interaction

"A system of knowledge, beliefs, behaviors, and customs shared by members of an interacting group to which members can refer, that serves as the basis of further interaction. Members recognize that they share experiences, and these experiences can be referred to with the expectation that they will be understood by other members."

-Gary Fine

“**Group culture** incorporates traditions and practices that are tied to background knowledge, common values, group goals and status systems, but also serves as a space in which new cultural items are performed that complement previous traditions” - Gary Fine

Hypothesis

A tornado warning is arguably the most challenging of all products issued by NWS forecasters. Sustained, high performance in tornado warnings, requires a highly-trained, dedicated staff who can work well as a team under very stressful conditions.

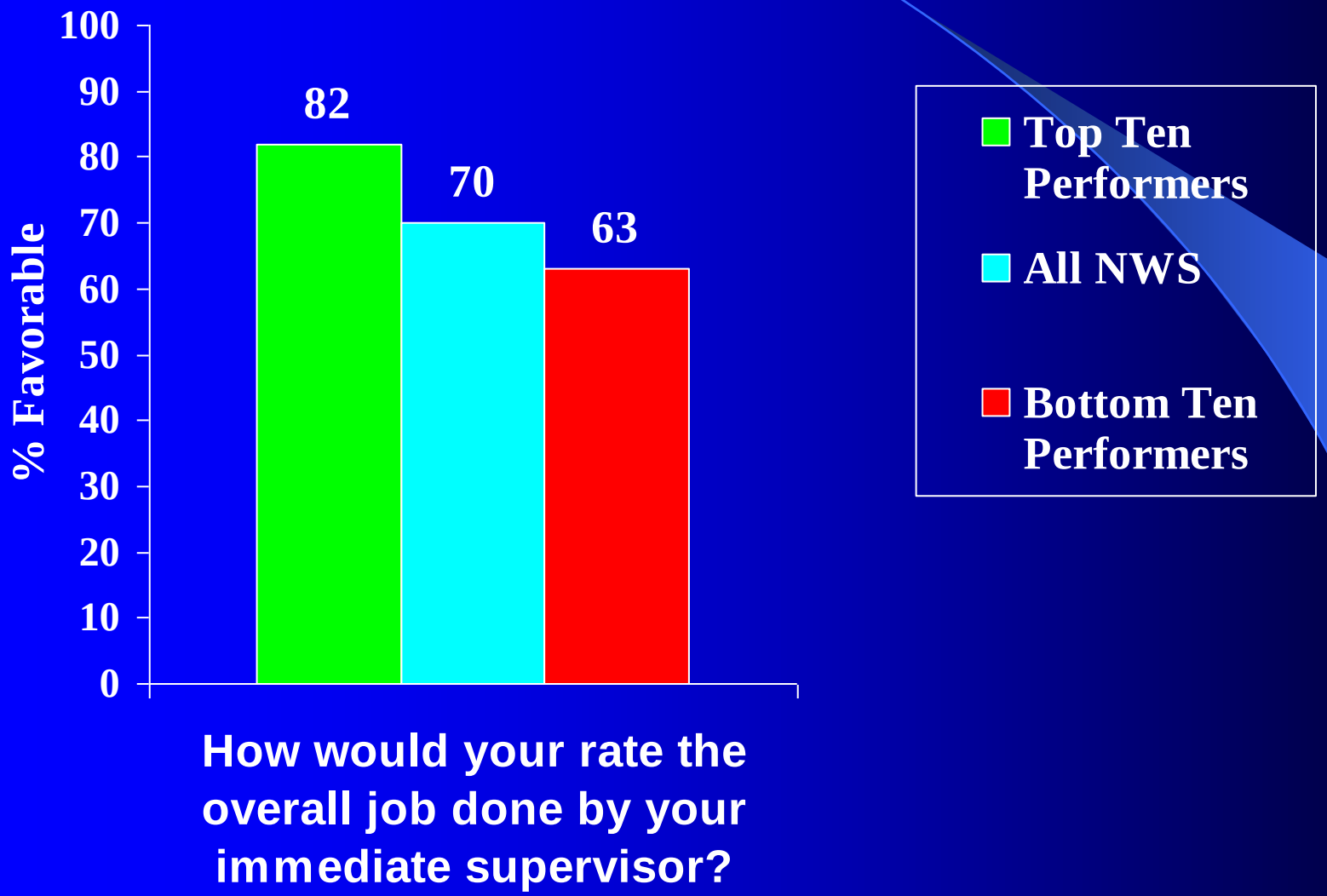
If the effects of group/office culture are to be seen, it would be in tornado warning verification statistics.

Offices that score high in tornado warning verification statistics will also score high in Employee Satisfaction Survey questions (proxy for WFO culture) compared to offices with poorer tornado verification statistics.

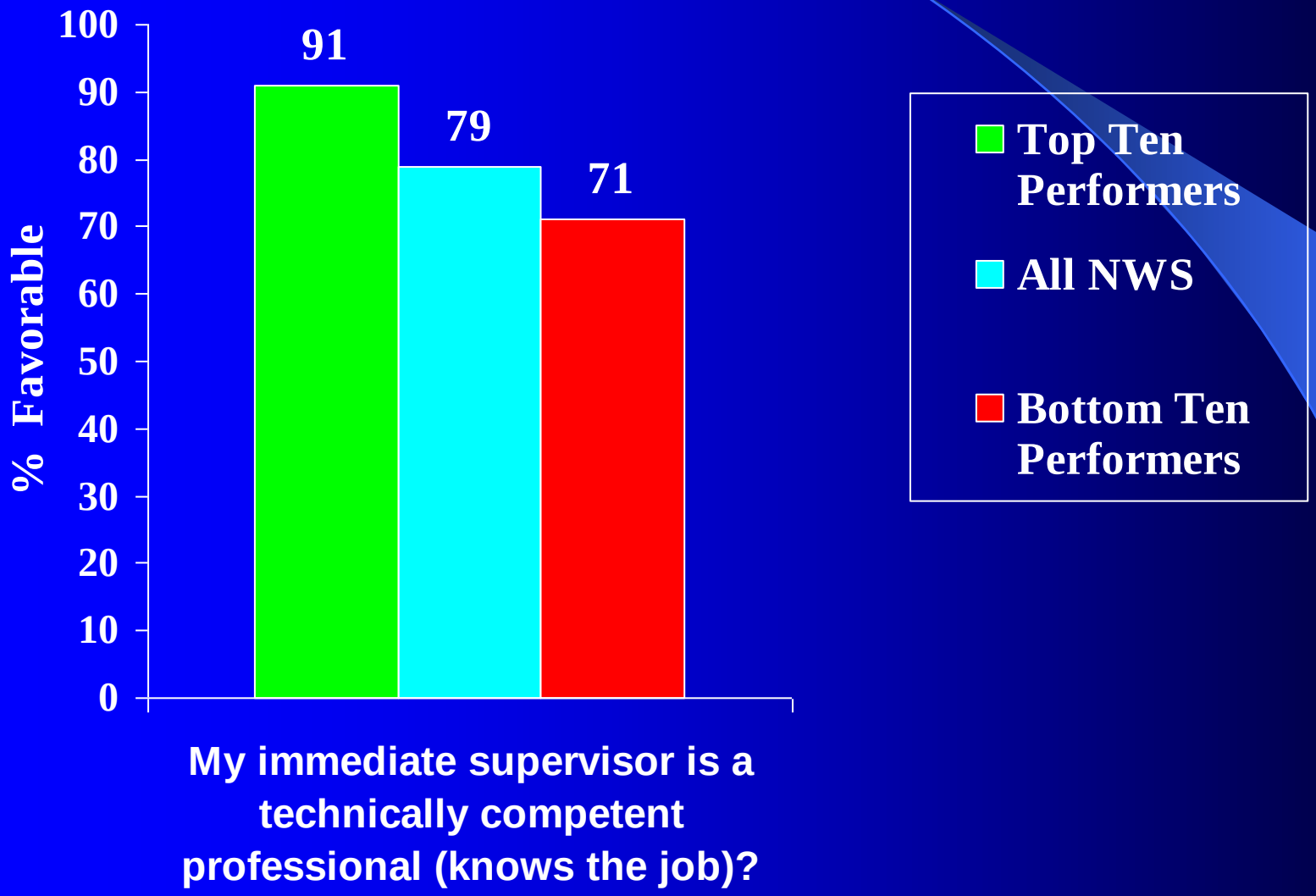
Methodology

- Obtained 2000 & 2001 Tornado Warning Statistics for each NWS forecast office
- Ranked all forecast offices by skill
- Requested a special aggregate report of NOAA's all-employee survey (SFA) for the Top 10 and Bottom 10 forecast offices in skill
- Compared the two reports for significant differences

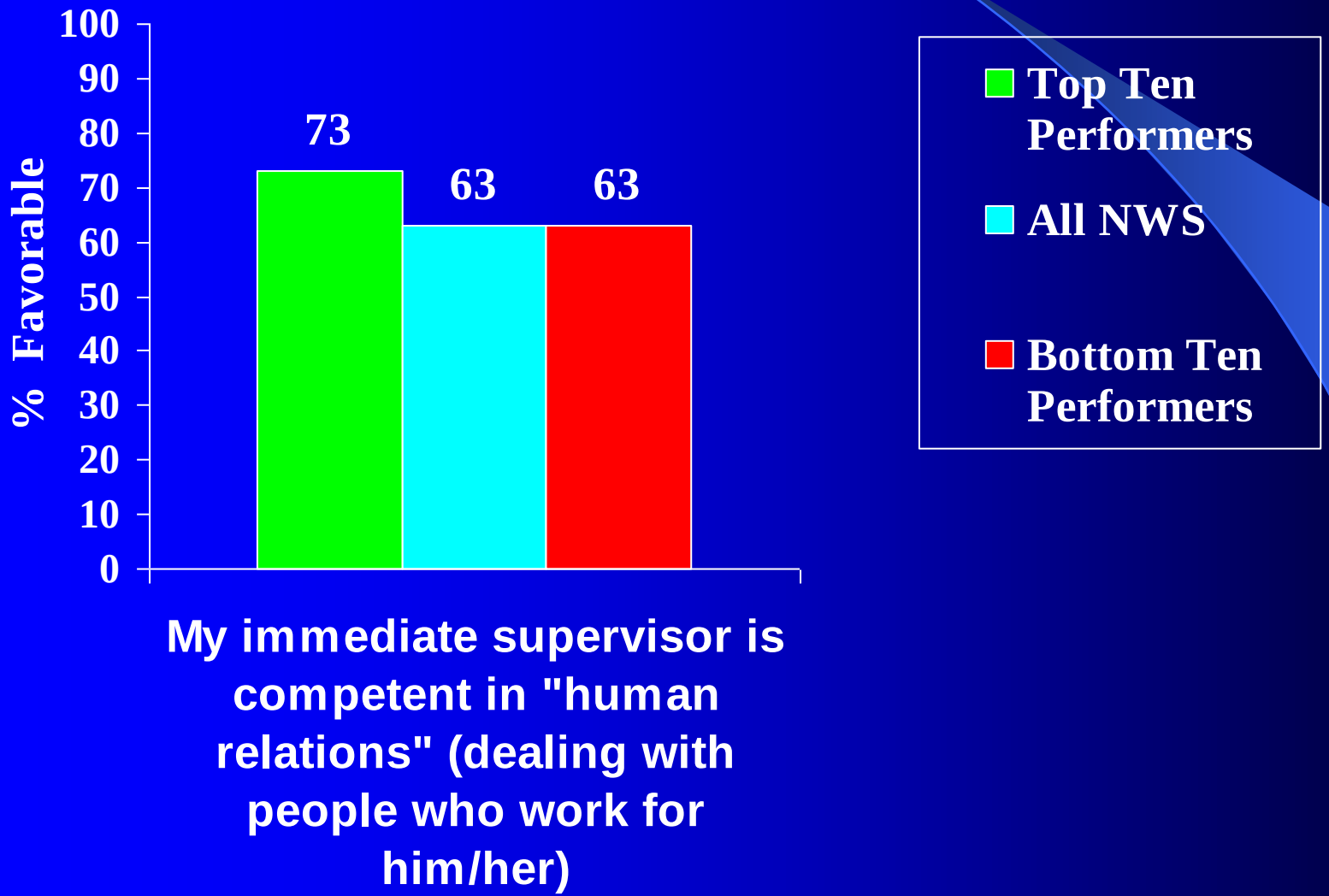
Supervision



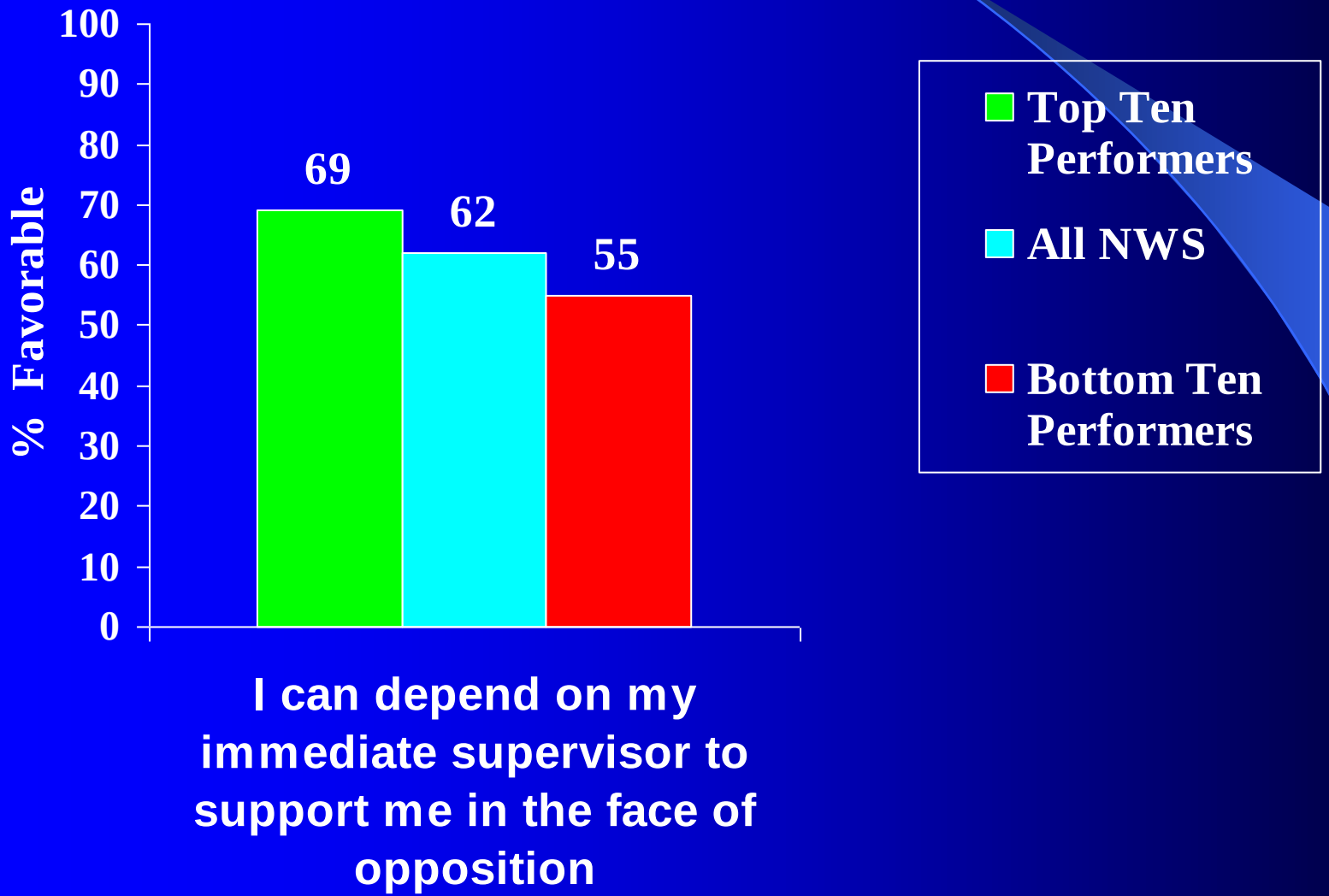
Supervision



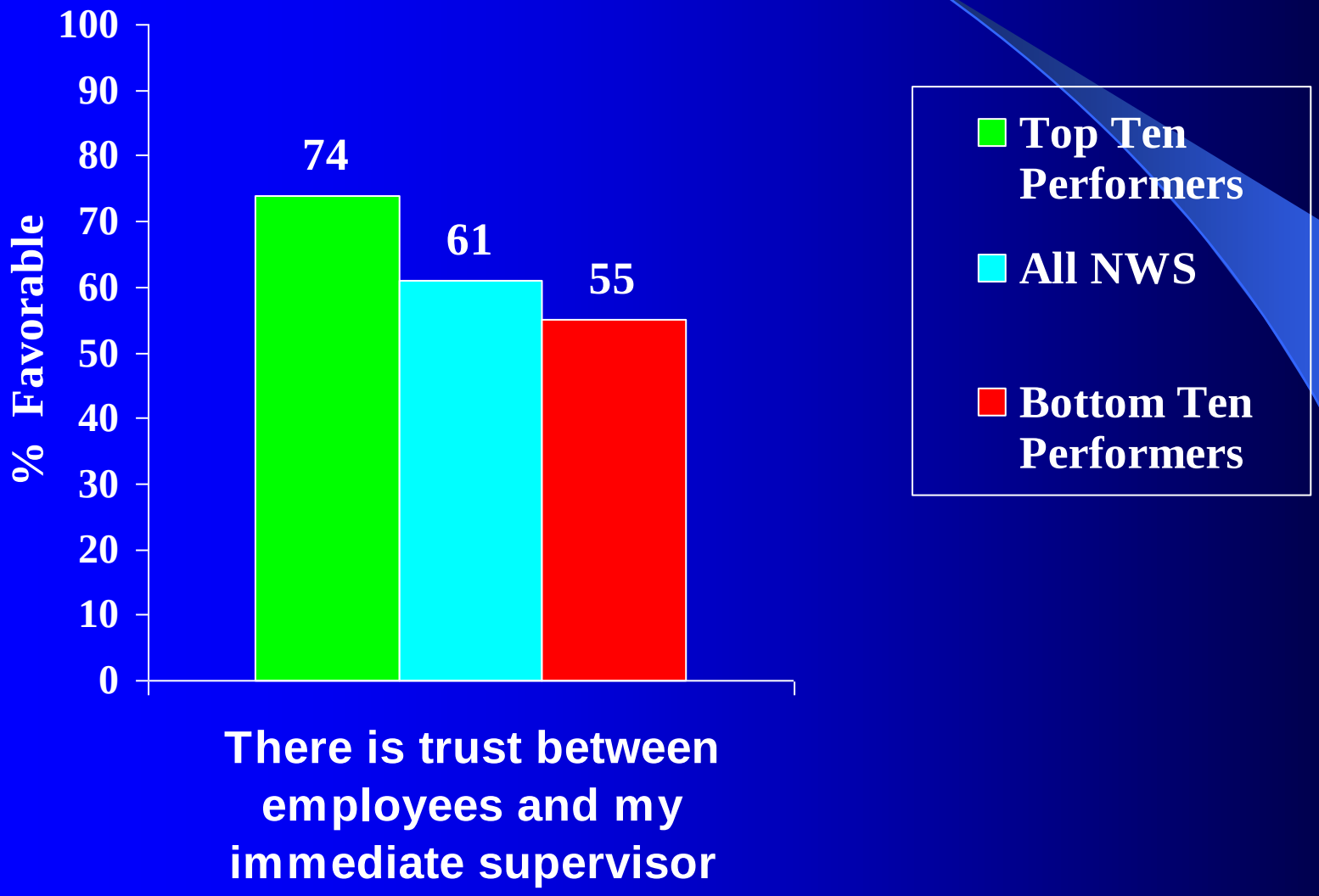
Supervision



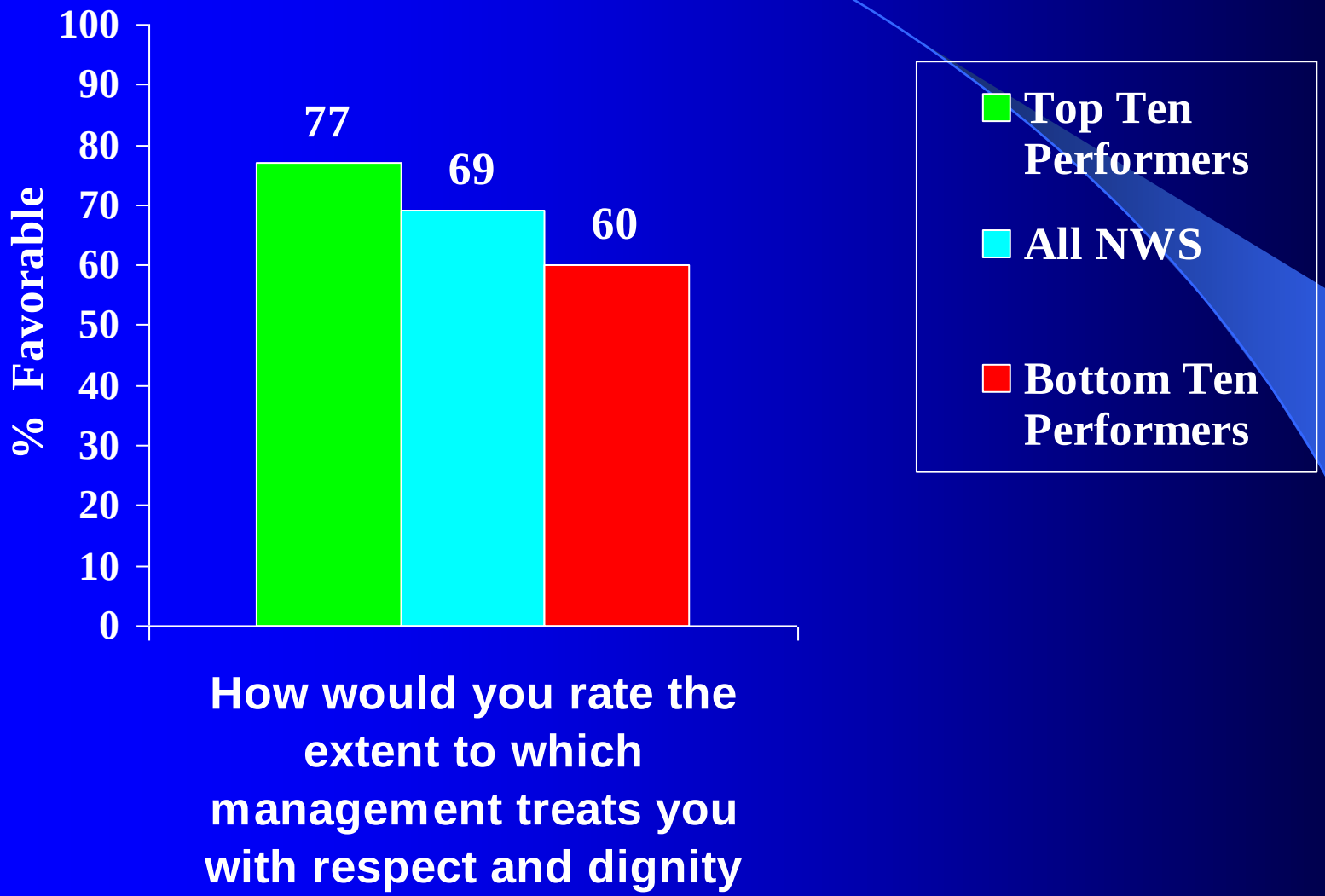
Supervision



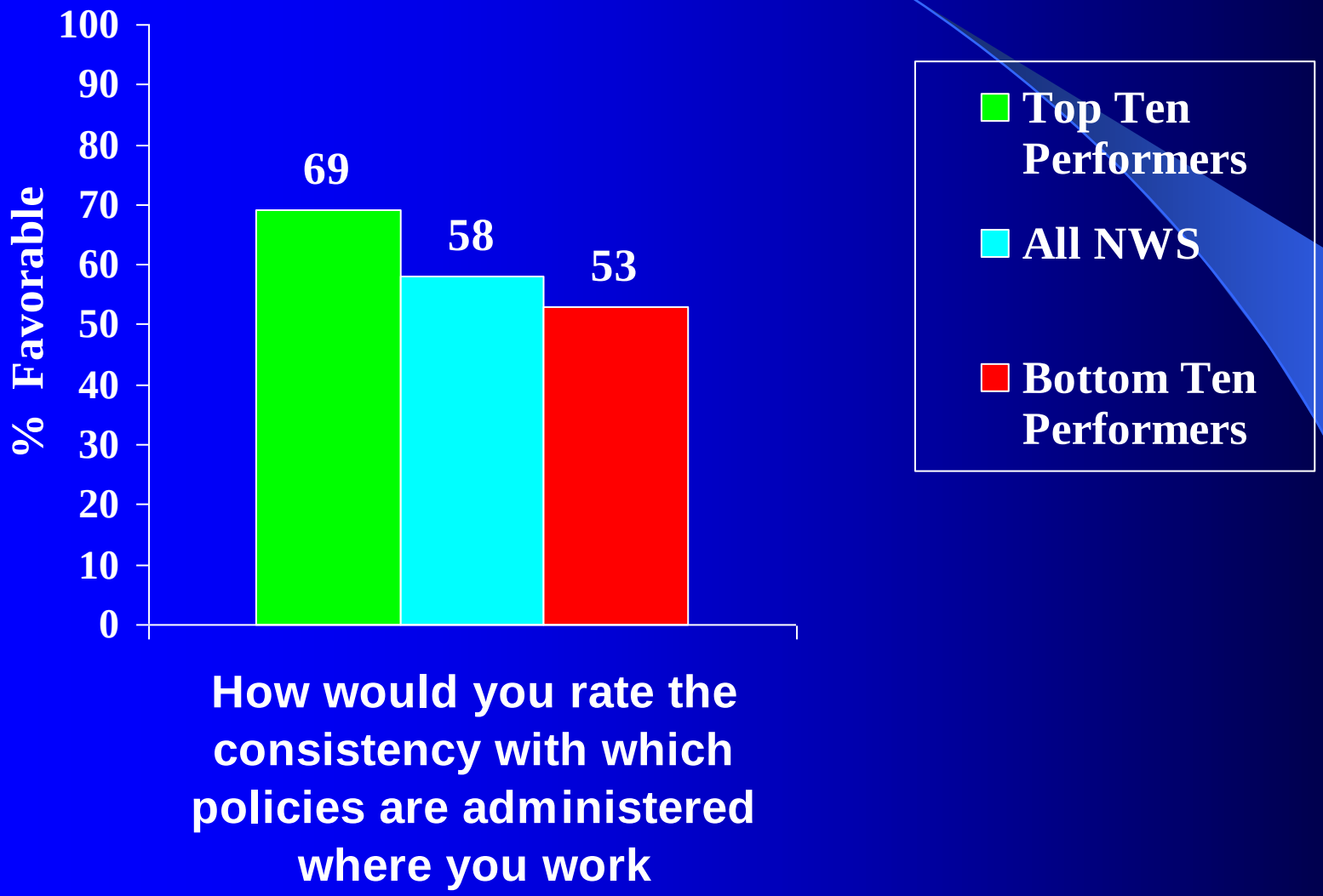
Fairness


100
90
80
70
60
50
40
30
20
10
0
% Favorable
74
61
55
Top Ten Performers
All NWS
Bottom Ten Performers
There is trust between employees and my immediate supervisor

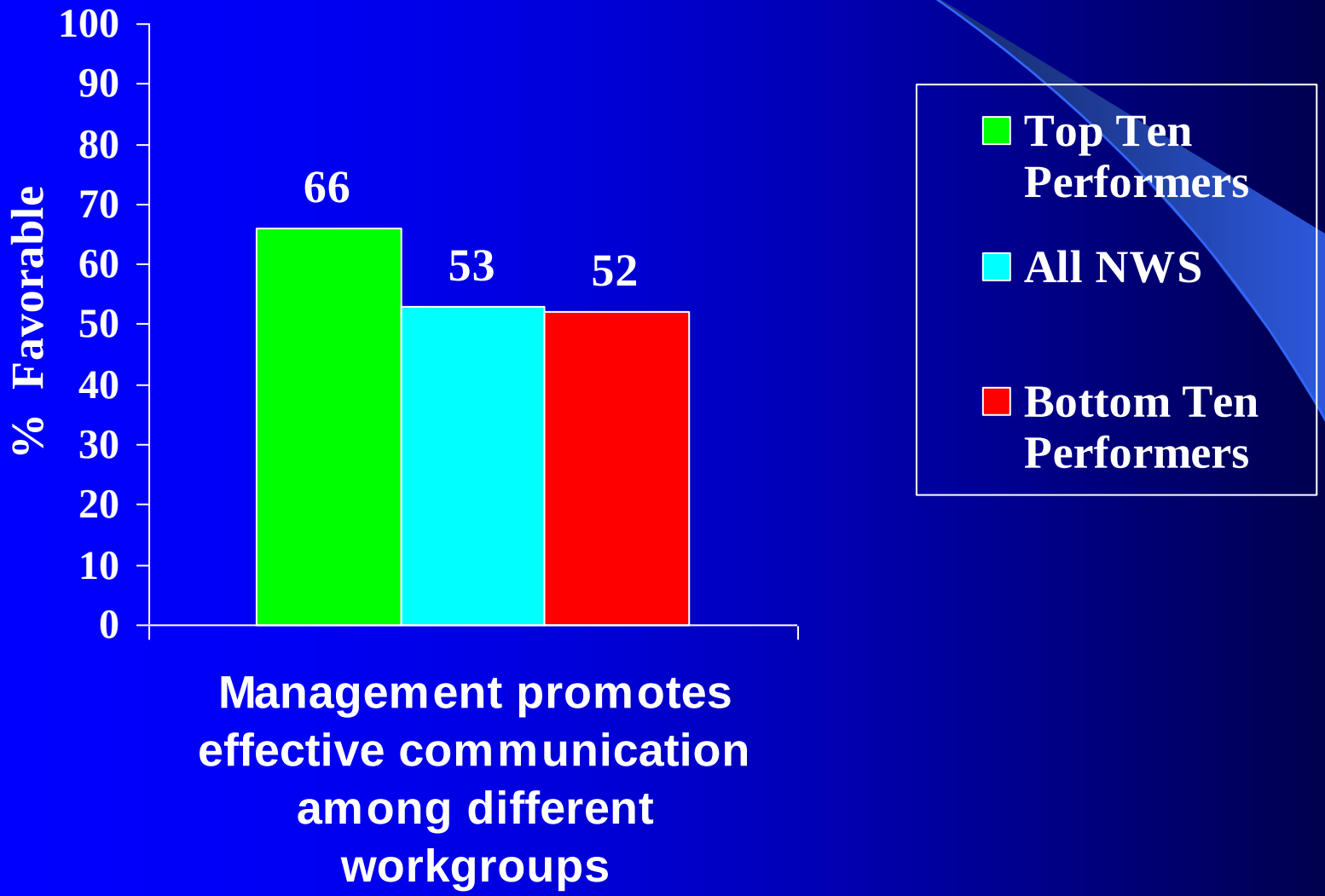
Fairness


100
90
80
70
60
50
40
30
20
10
0
% Favorable
77
69
60
Top Ten Performers
All NWS
Bottom Ten Performers
How would you rate the extent to which management treats you with respect and dignity

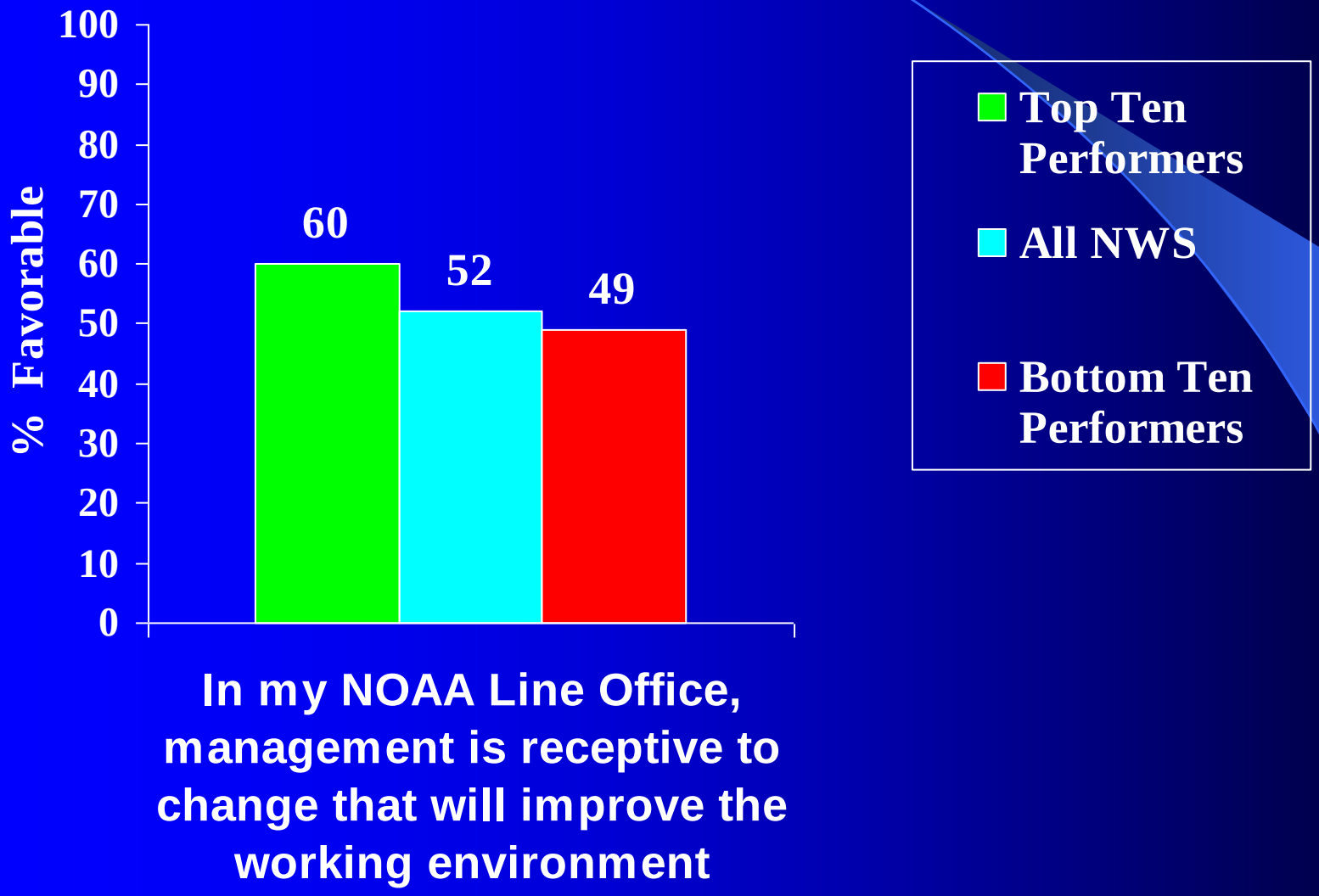
Fairness


100
90
80
70
60
50
40
30
20
10
0
% Favorable
69
58
53
Top Ten Performers
All NWS
Bottom Ten Performers
How would you rate the consistency with which policies are administered where you work

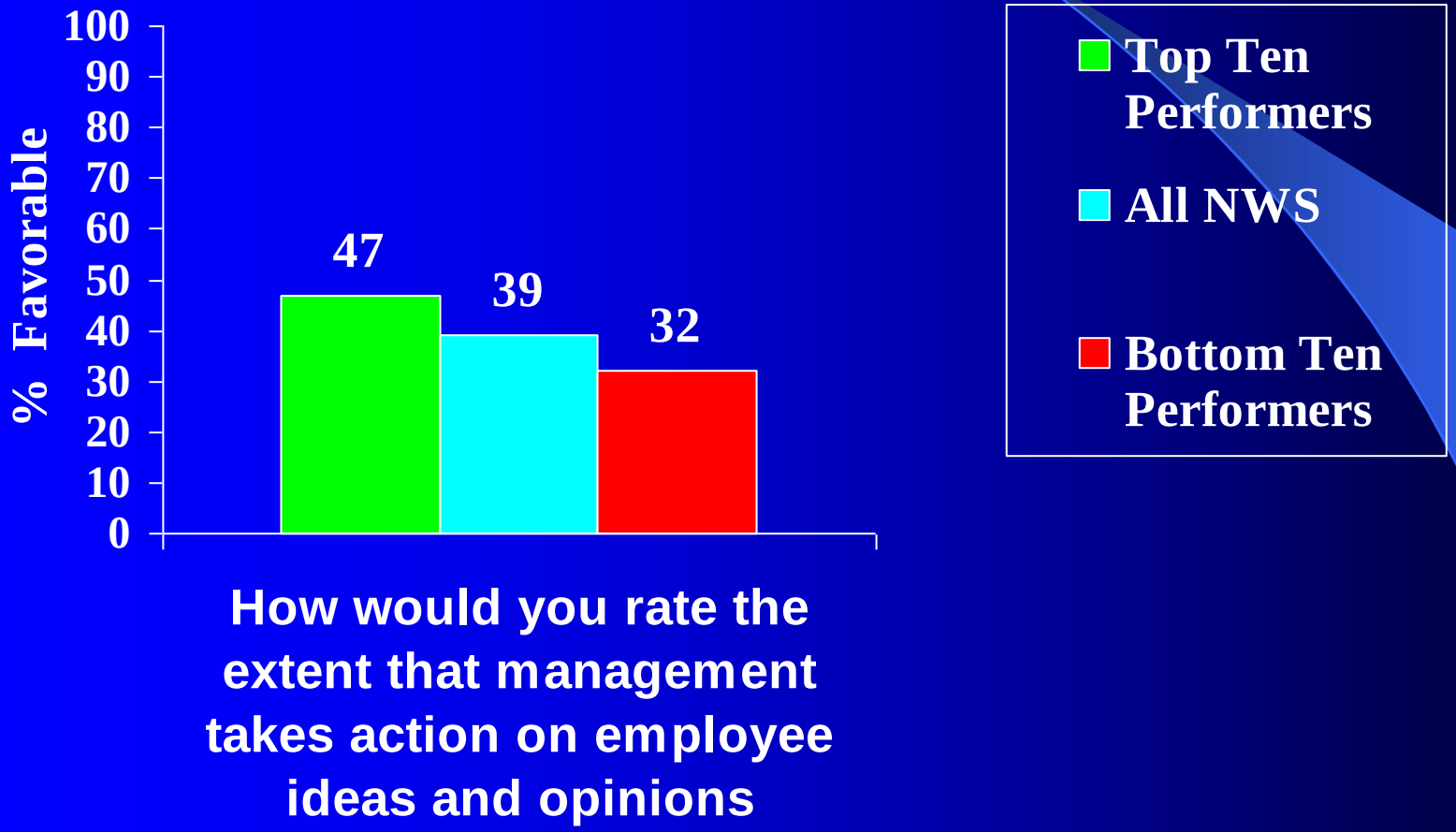
Communication



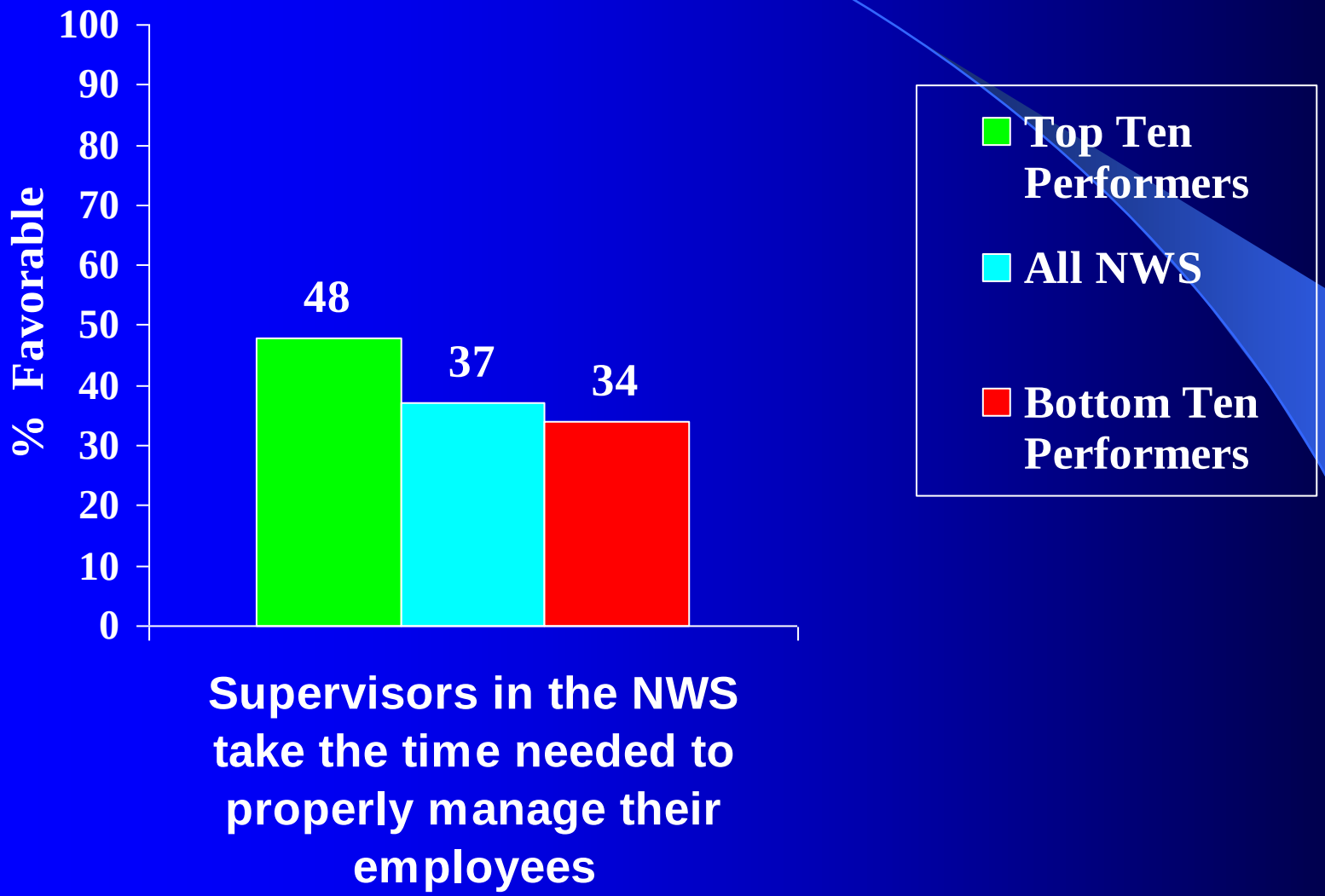
Innovation


100
90
80
70
60
50
40
30
20
10
0
% Favorable
60
52
49
Top Ten Performers
All NWS
Bottom Ten Performers
In my NOAA Line Office, management is receptive to change that will improve the working environment

Leadership


% Favorable
100
90
80
70
60
50
40
30
20
10
0
47
39
32
Top Ten Performers
All NWS
Bottom Ten Performers
How would you rate the extent that management takes action on employee ideas and opinions

Supplemental Questions



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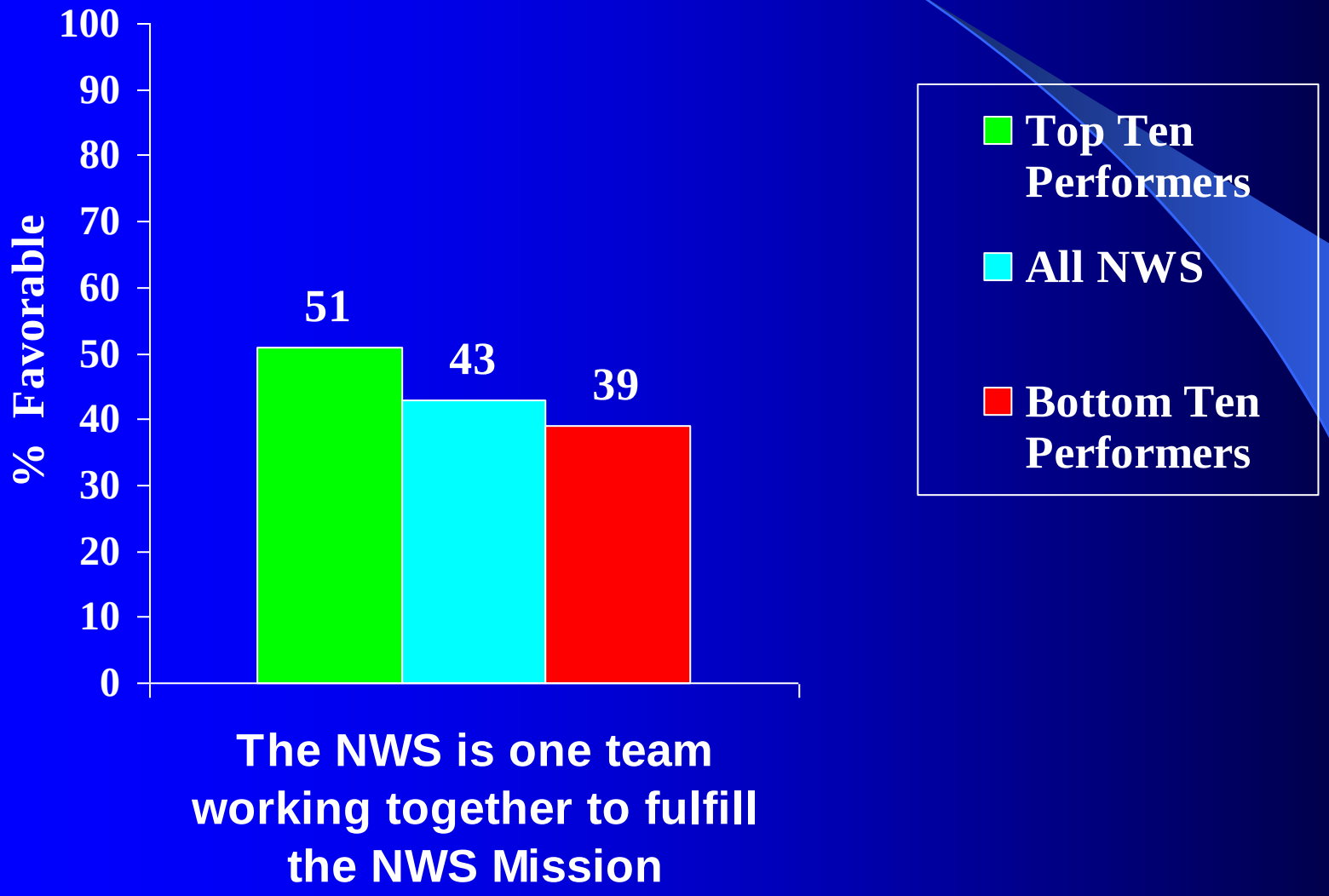
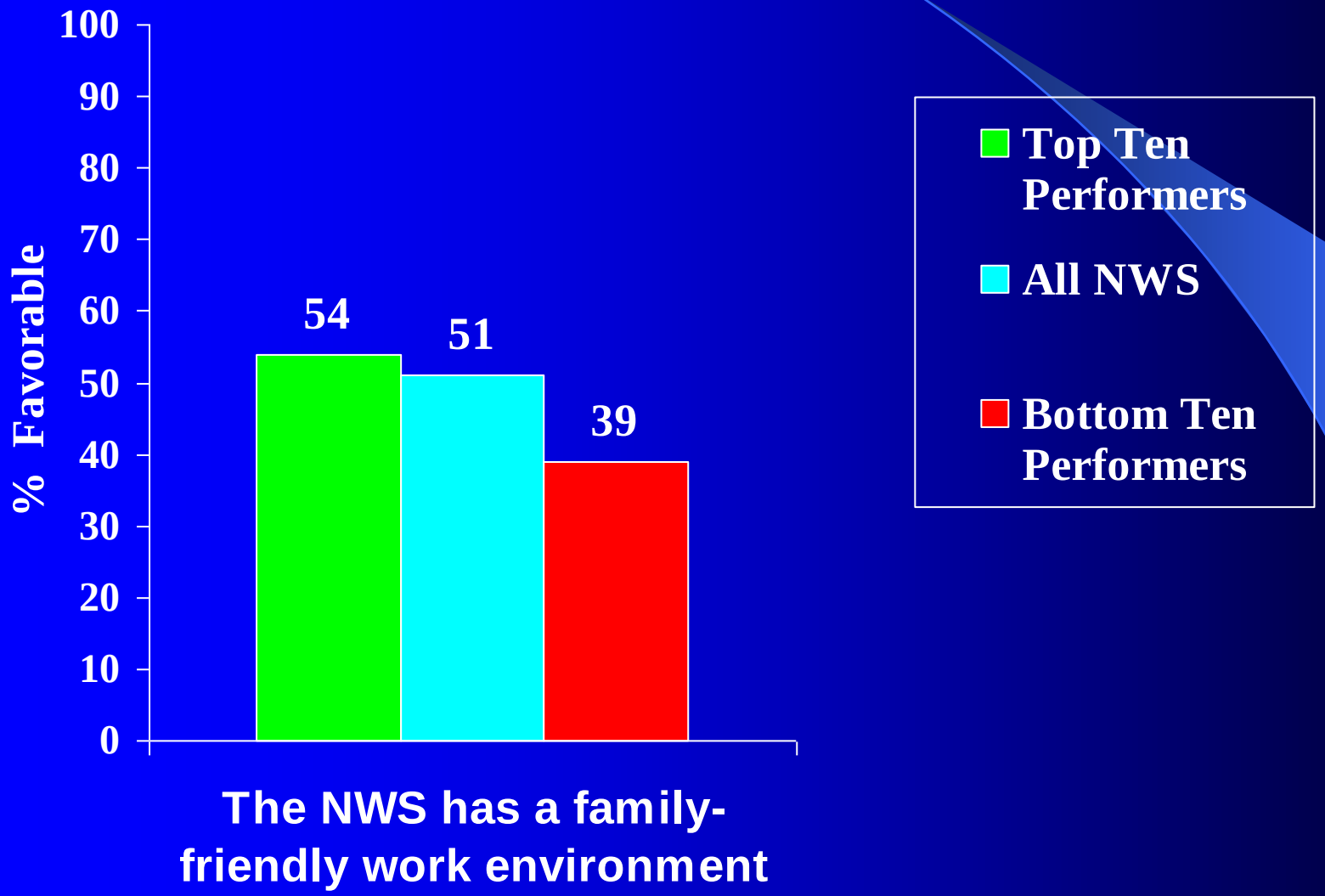


Supplemental Questions



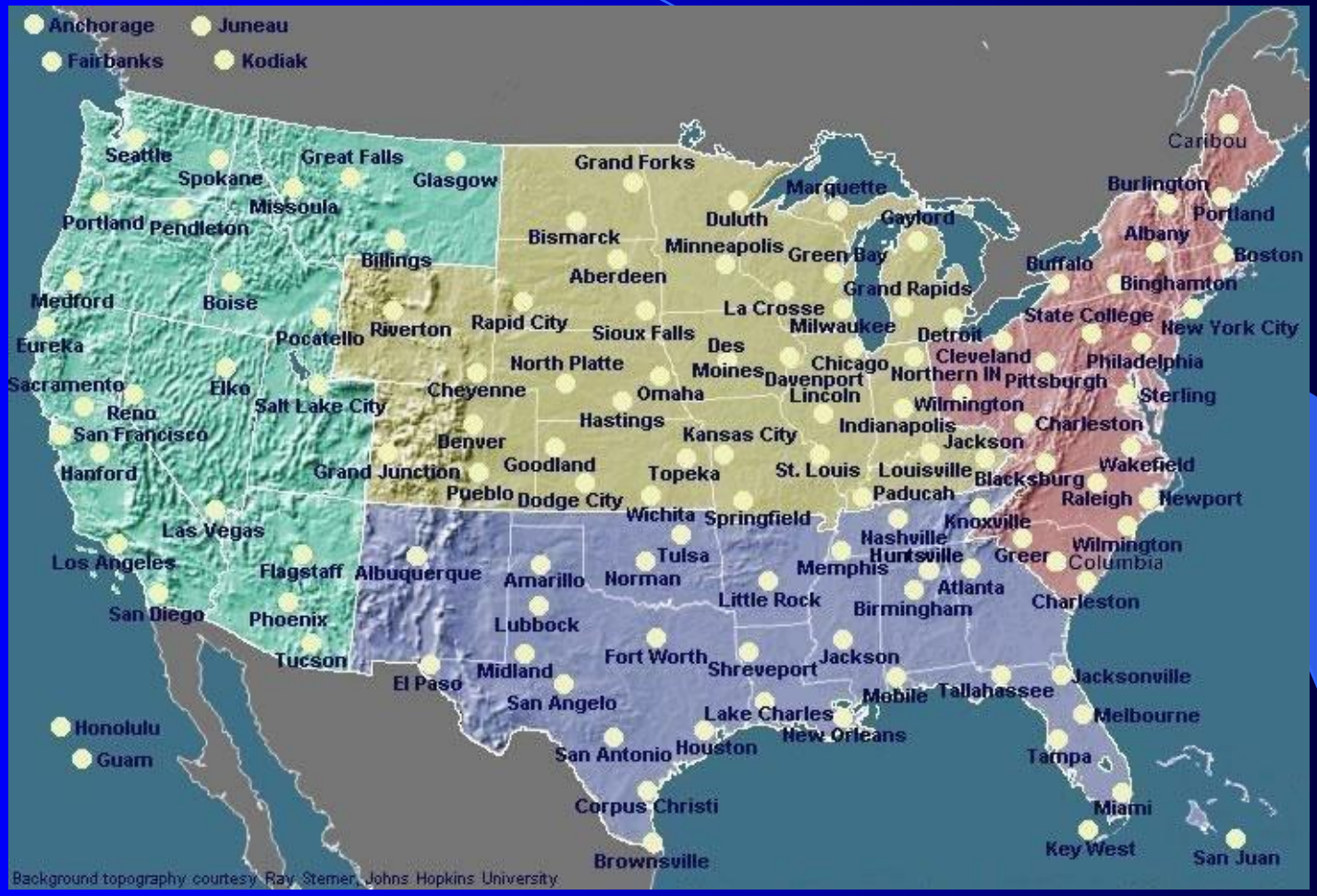
Findings from Phone Interviews of Top Ten Forecast Offices

- Manager leadership demonstrated through action (working shifts, severe weather) often in a subordinate role
- Managers do not micro-manage severe weather operations
- Some managers had anti-role models
- Managers back up their forecasters' decisions
- Managers foster open dialog
- Managers are careful in hiring people to enhance the existing team (consider both skills and personality)
- Office commitment to improvement

Findings from Phone Interviews of Top Ten Forecast Offices

- Managers work closely with the union representatives
- Managers support family/personal needs
- Offices seem to have low staff turnover
- Managers have strong focus on making the work satisfying and enjoyable for their employees
- Managers work to make sure that all employees are appreciated (both mets and non-mets)
- Managers reward quickly and often
- Management team support manager's goals

NWS Forecast Offices and Regions *



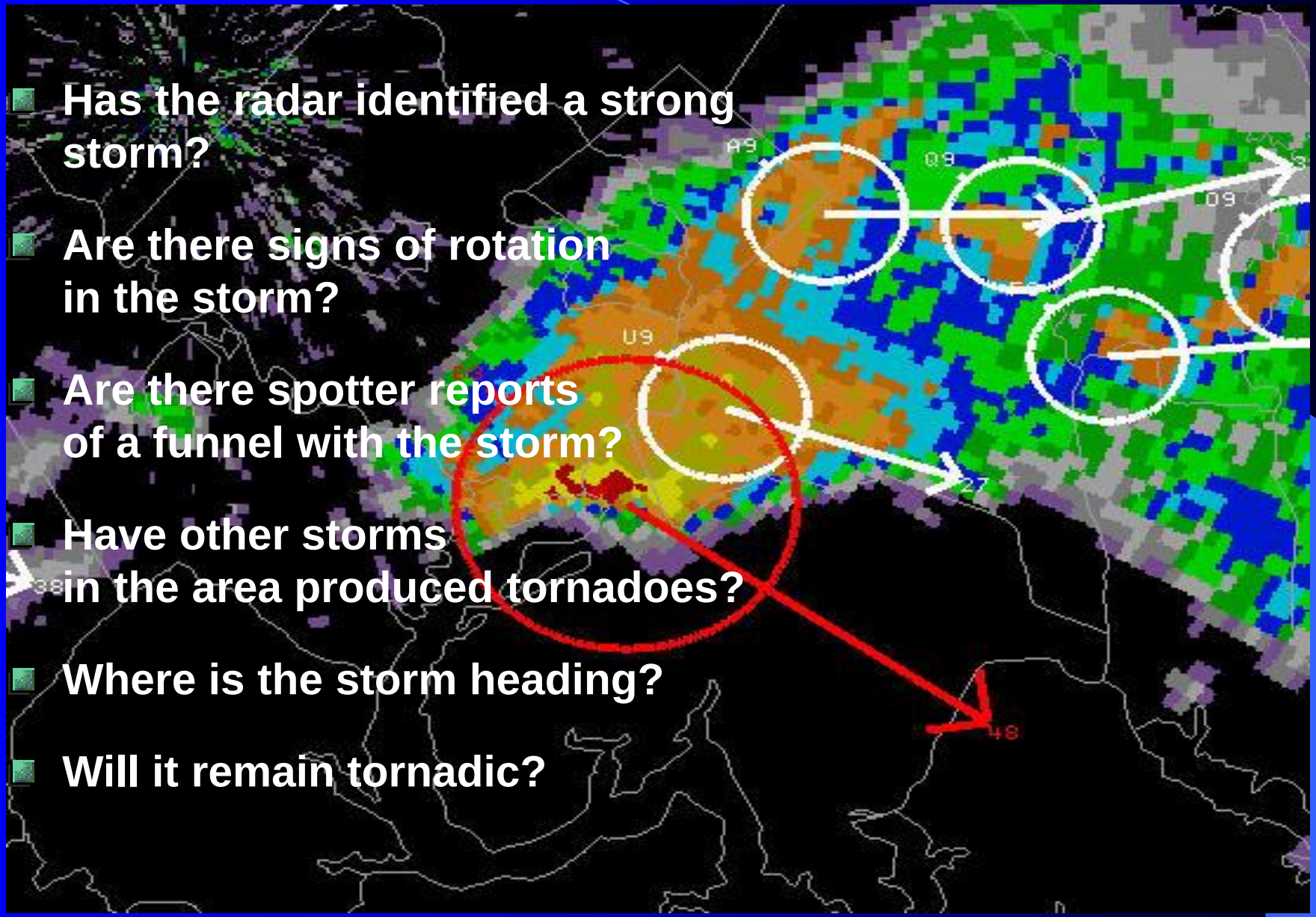
**** Offices west of the Rockies were excluded from our analyses, as well as those reporting fewer than five tornado events in 2001/2002 and those with fewer than five employees completing the survey.***

Weather Forecast Office (WFO) Culture

Characteristics

- "Family" unit of 20-30 people, isolated from other offices
- Relatively homogenous in gender, ethnicity, age
- Experienced (10-25 yrs)
- Unionized
- High value placed on Science and Technology and Dedication to Mission

Which Storms are Tornadic?



- Has the radar identified a strong storm?
- Are there signs of rotation in the storm?
- Are there spotter reports of a funnel with the storm?
- Have other storms in the area produced tornadoes?
- Where is the storm heading?
- Will it remain tornadic?

Key Measures on 50 WFOs

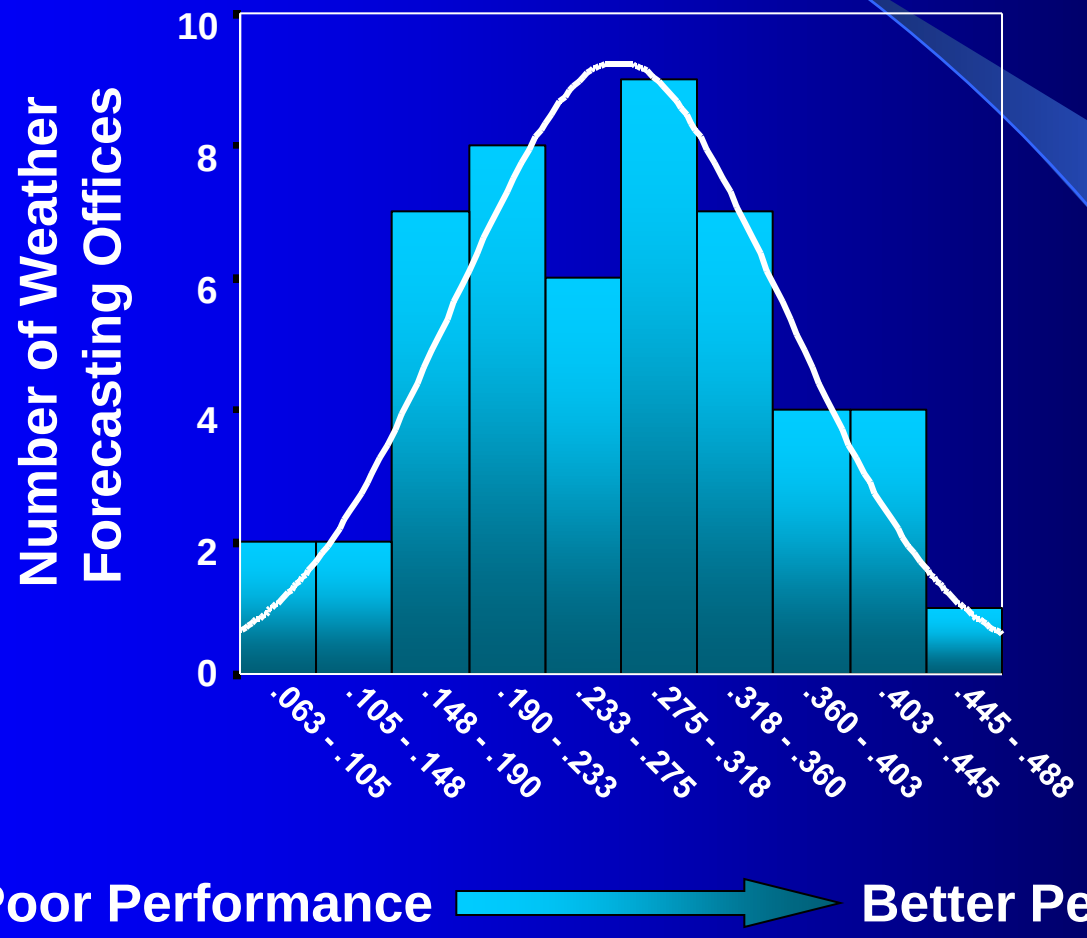
- **Data for 50 Weather Forecast Offices:**
  - **Critical Success Index (CSI) – key measure of tornado warning performance that combines hits, misses, and false alarms**
    - **Hits: Number of positive forecasts followed by an event occurrence**
    - **Misses: Number of occurrences that were not predicted**
    - **False Alarms: Number of positive forecasts that were not accompanied by an event**
  - **Sick leave hours per month per employee**
  - **Employee Satisfaction – from a Sirota survey of 12,000 National Oceanic and Atmospheric Administration (NOAA) employees**
    - **Conducted as part of a diversity strategy**
    - **Approximately 130 multiple-choice questions**
    - **Administered through February of 2002**

Key Measures on 50 WFOs (continued)

- **Data on 50 Weather Forecast Offices (continued):**
  - **Controlled variables – several variables thought to affect tornado warning performance accuracy were statistically controlled for:**
    - **Employee tenure**
    - **Education level**
    - **Number of employees at each site**
    - **Geography**
    - **Number of tornado events**
    - **F-Scale of tornadoes**
  - **Other potential influences were comparable across the offices:**
    - **Technology**
    - **Training opportunities**

Variation in CSI Scores Across Offices

Research Question: How do we explain these CSI performance differences for tornado warnings across WFO's?



Results

- Out of 149 questions, 131 (88%) were positively correlated to CSI for Tornado Warnings
- Null hypothesis of a random relationship between SFA results and CSI can be rejected with an enormous degree of confidence (0.0000000…..1)
- Of the 18 correlations that were negative, none were significant at the .05 level
- Of the 131 that were positive, 27 were significant at the .05 level

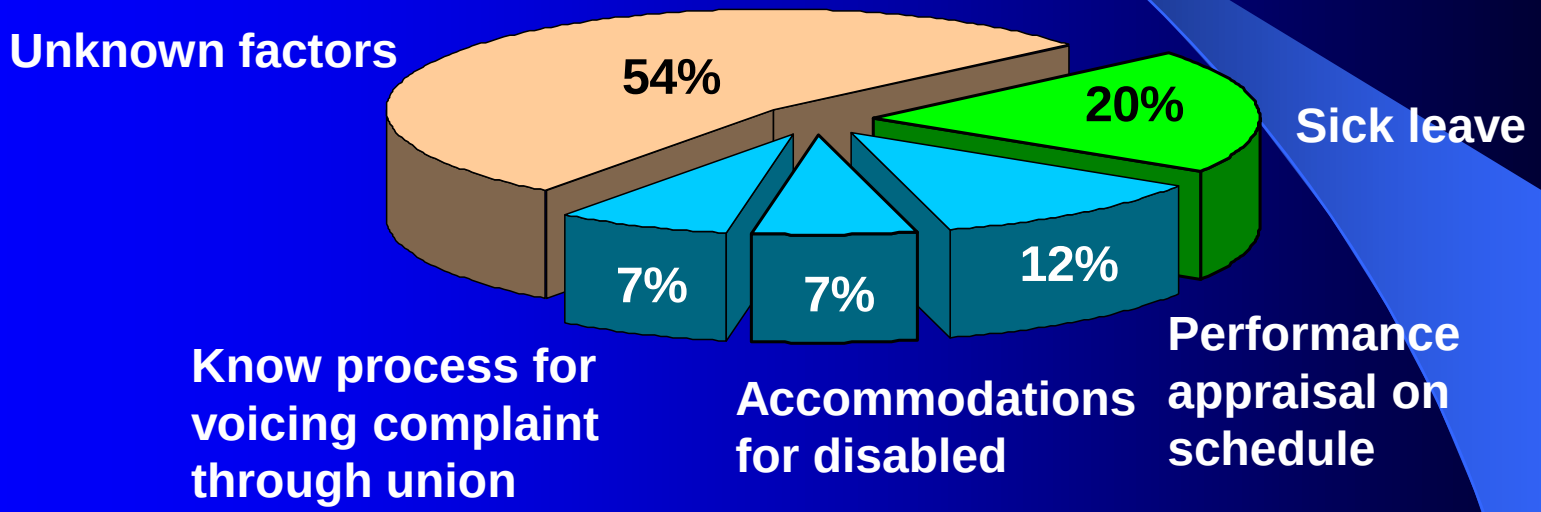
Highest Correlates of Tornado Warning Performance

	r
Sick leave hrs per month per employee (actual sick leave hours per month)	-0.45**
My last performance appraisal was on schedule	0.42**
Reasonable accommodations are made for persons with disabilities (e.g., availability of sign language interpreters, ramps, Braille)	0.38**
I know the process for voicing a complaint or filing a grievance through the union	0.36**
In my Line/Staff Office, work practices and procedures that are no longer needed are eliminated	0.34**
I understand the relationships between the NOAA Line/Staff Offices	0.30*
Differences among individuals are understood and accepted (e.g., gender, race, religion, age, sexual orientation, disability)	0.28*
Diverse groups (e.g., work teams, customers) participate in the development of performance measures where I work	0.28*
The results of the 1998 SFA were used constructively by management	0.26*
I know where to find information concerning my rights as a federal employee	0.25*
I know how to contact the appropriate union official if I need to	0.24*
I understand that the union is the exclusive representative of NWS bargaining unit employees	0.24*

*Pairwise $n = 50$; * $p < .05$; ** $p < .01$*

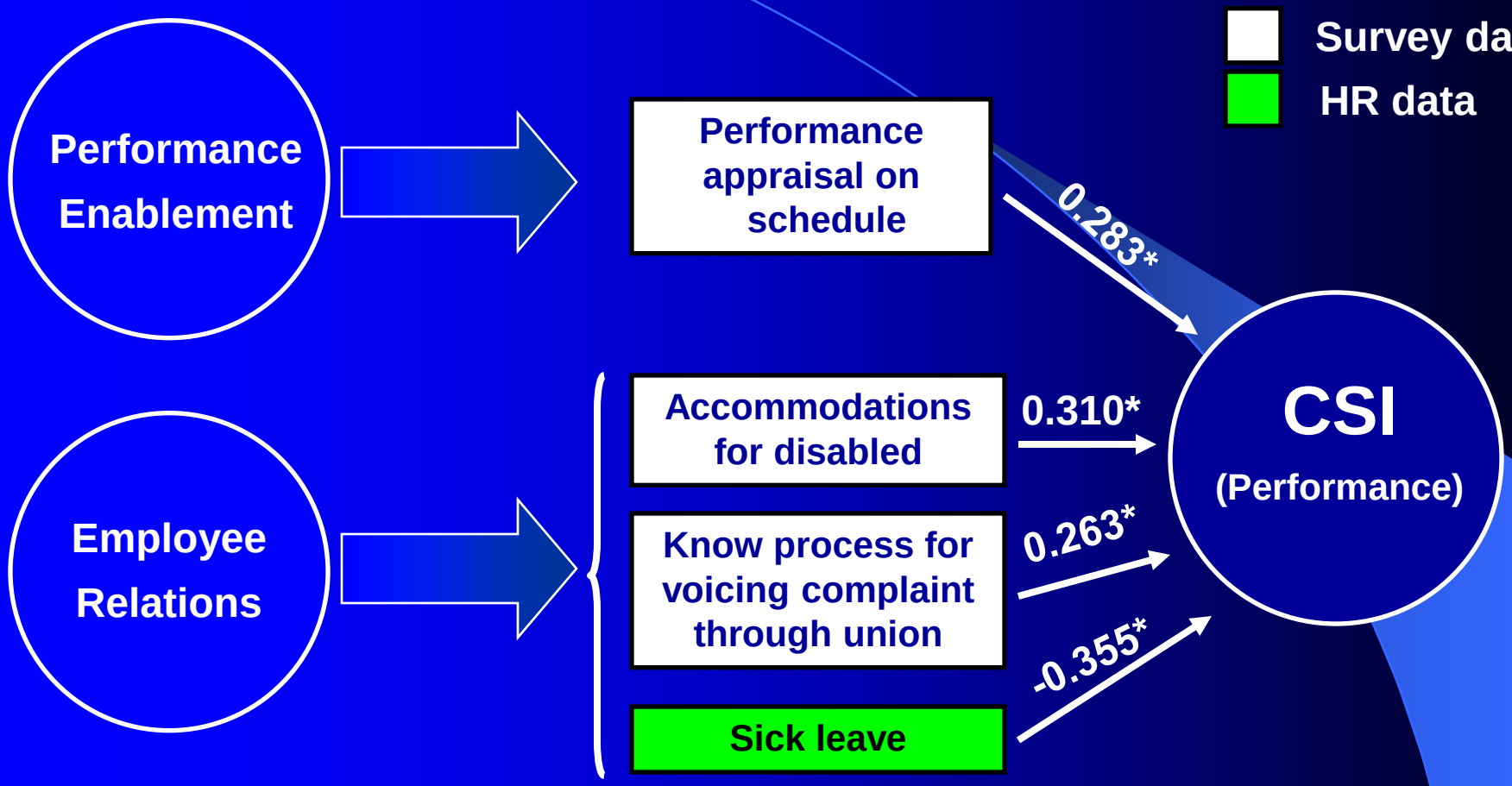
Regression Analysis

Nearly half of the differences in WFOs' performance are accounted for by four variables:



*** Results based upon stepwise regression analysis**

Conceptual Model



The most important factors in tornado warning performance reflect managerial effectiveness: Performance Orientation and Employee Relations

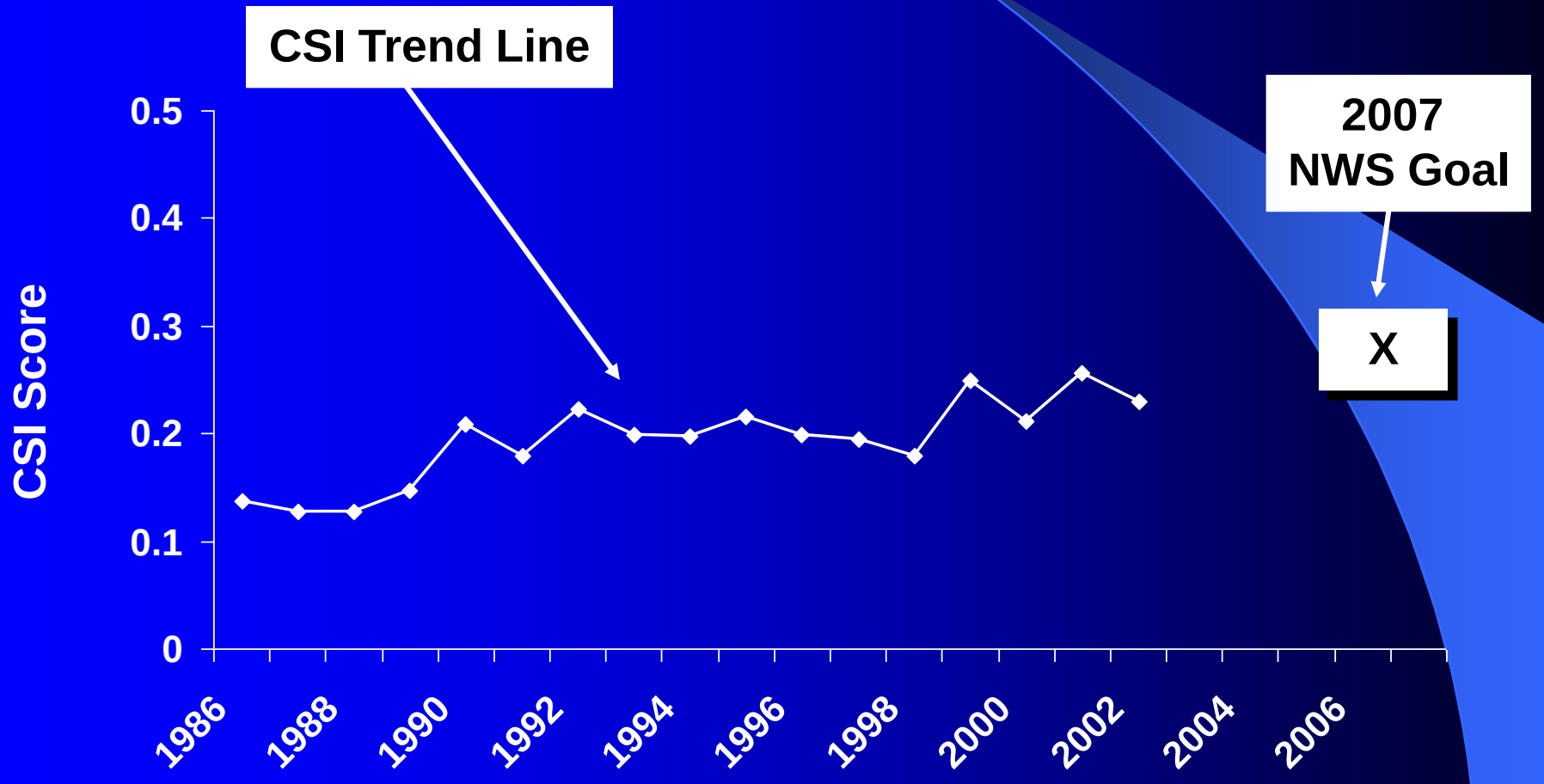
*** Values are Standardized Beta coefficients**

Highest Survey Correlates of Sick Leave

- **A clear pattern of relationships emerges:**
  - **Work group cooperation and teamwork**
    - **Within work groups (r = -0.30 *)**
    - **Between work groups (r = -0.41 **)**
  - **Supervisor behavior**
    - **Responsive to employee ideas (r = -0.40 **)**
    - **Fair (r = -0.36 *) and Supportive (r = -0.35 *)**
    - **Relationship with union representative (r = -0.40 **)**
  - **Performance and diversity**
- **In other words . . .**
  - **WFO culture has a strong and consistent impact on sick leave**
  - **And, ultimately on tornado warnings**

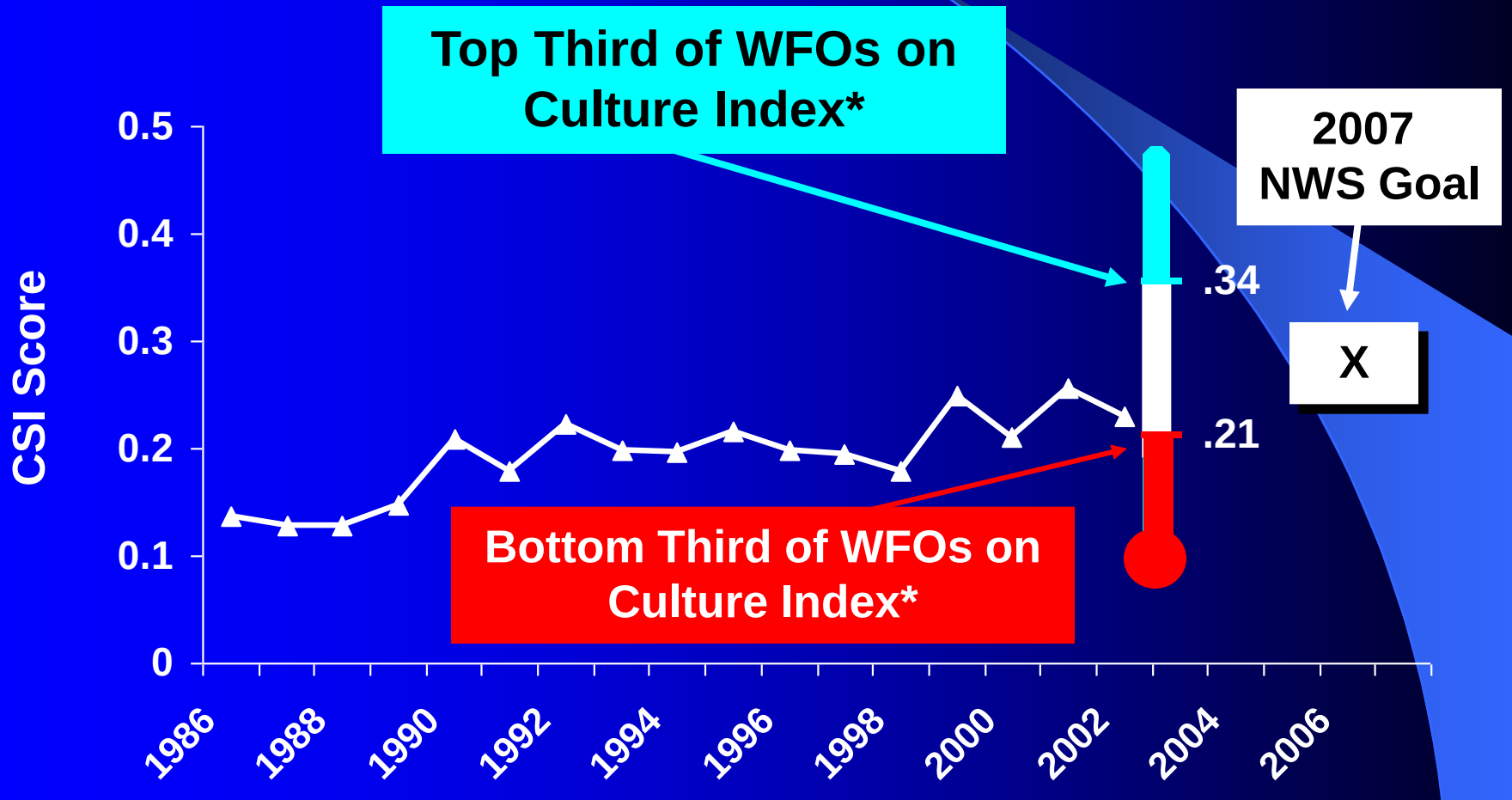
p < .05; ** p < .01

NWS Tornado Warning Performance



NWS Tornado Warning Performance

WFOs performing best on cultural variables have reached the NWS goal four years ahead of schedule:



*The Culture Index comprises the following items: Performance appraisal on schedule, Accomodations for disabled and Know process for voicing complaint through union

Conclusions - Part I

- **Improvements in technology and advancements in science are extremely important to improve tornado warning performance. They promise to raise the performance of *all* offices.**
- **In addition, we have found that leadership in *individual* National Weather Service offices also has a demonstrable impact on performance.**
- **In fact, the quantitative goal of excellence the National Weather Service has set for itself could be achieved by attending to these cultural variables alone.**

Conclusions - Part I (cont.)

- **Where a high performance culture is in place, a better job is done carrying out the National Weather Service mission!**
- **Where a high performance culture is in place, the cost of carrying out the National Weather Service mission is reduced!**
- **SFA 2002 results show that the National Weather Service should focus on aligning the management practices in all its offices with those that foster of a culture of high performance . An improvement strategy based only on science and technology without an aggressive human relations component is likely to fall short of the mark.**
- **This is the Business Case for non-technical (leadership, diversity, communication, etc) training for the National Weather Service**

High Performance Culture

CHARACTERISTICS
Flexible Policies/Procedures
Teamwork
Open Communication
Focus on Performance
Goals Set and Tracked
Strong Customer Orientation
Emphasis on Innovation
Trust and Respect
Good Relations with Union

Highly Accurate Warnings
Low Sick Leave

Low Performance Culture

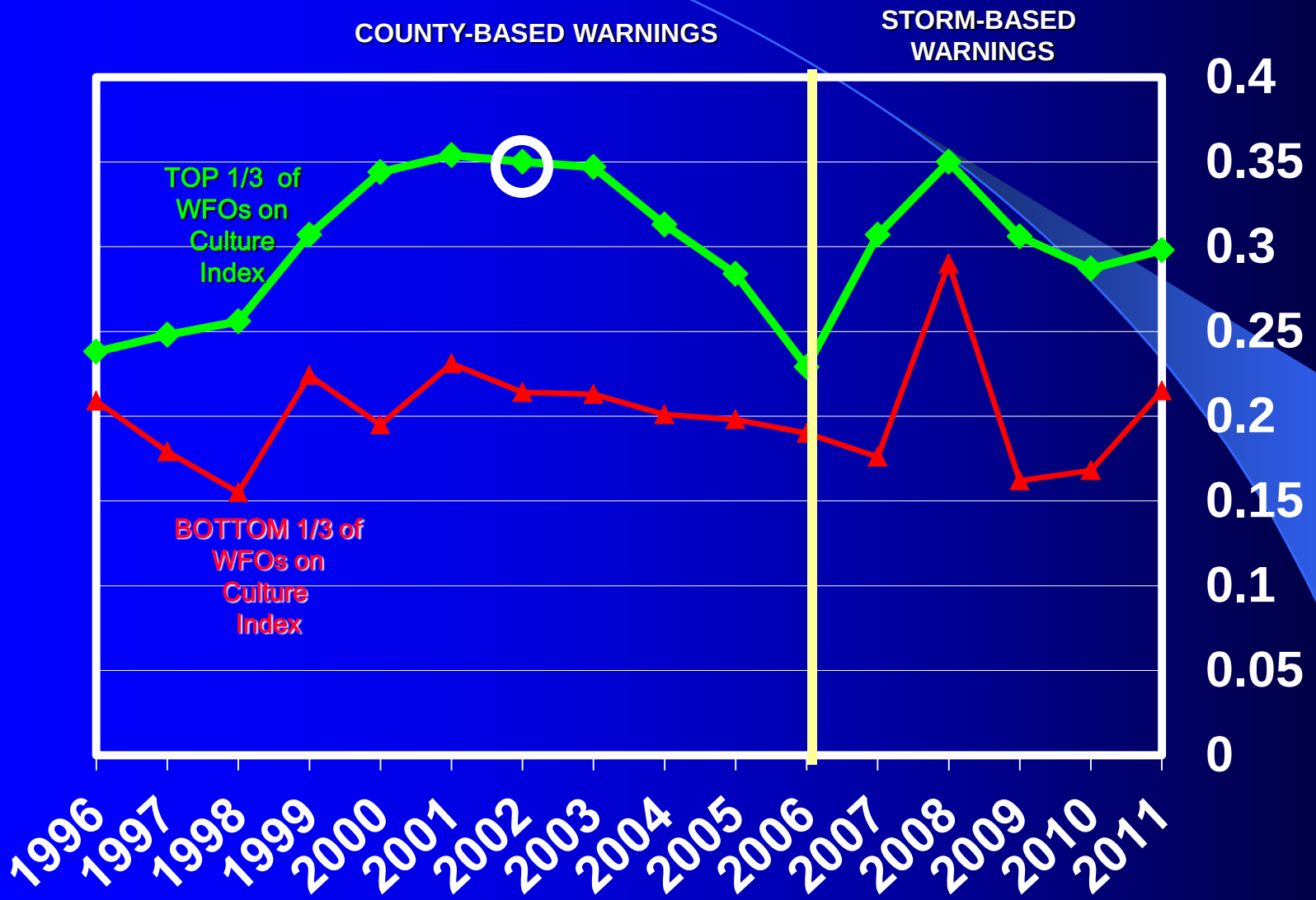
CHARACTERISTICS
Rigid Policies/Procedures
Unresolved Conflict
Climate of Fear
Lack of Empowerment
Poor Sense of Goals
Lack of Customer Focus
Resistance to Change
Ignorance of Diversity Issues
Poor Relations with Union

Moderately Accurate Warnings
High Sick Leave

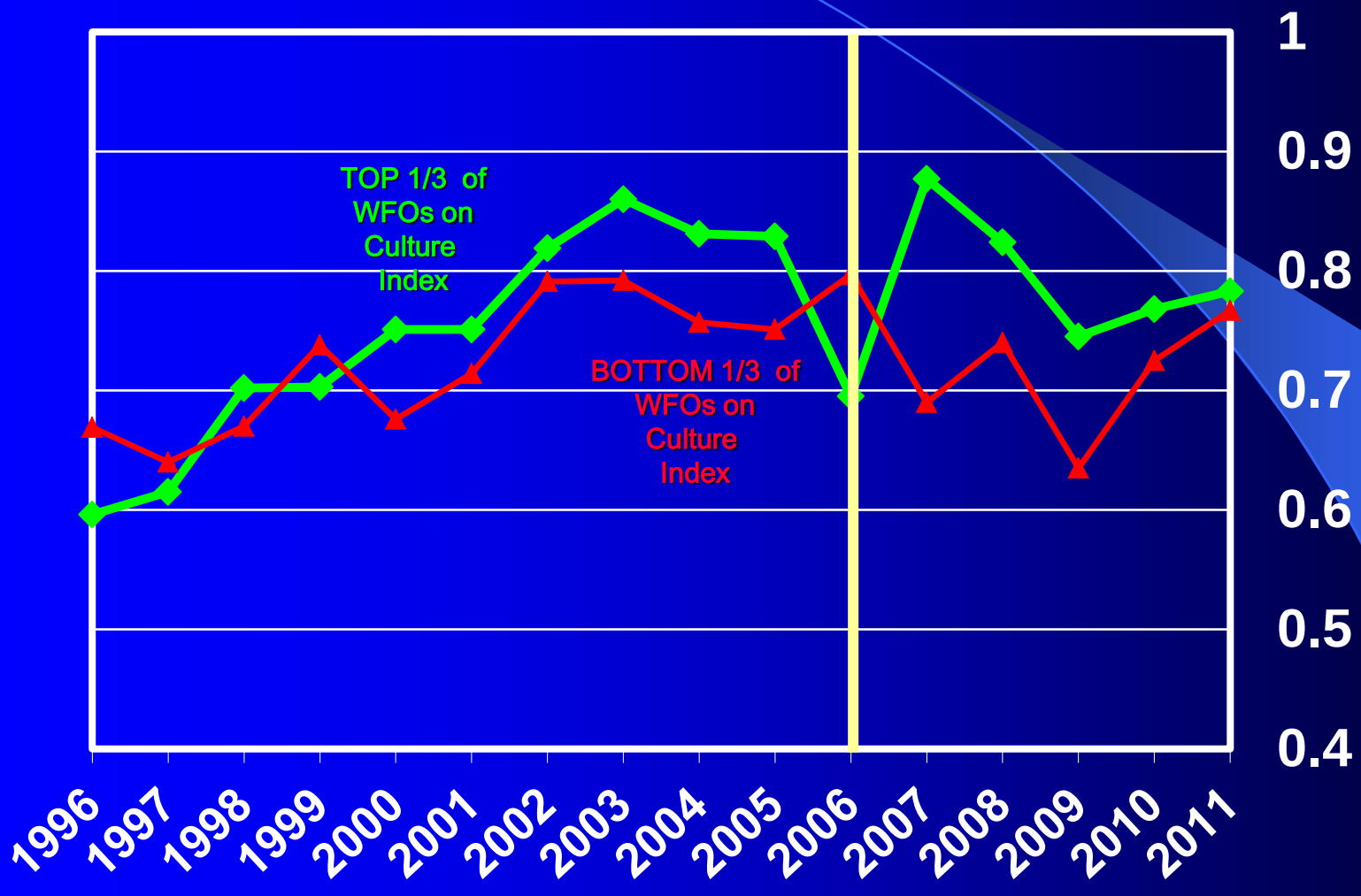
That was a *snapshot* from nine years ago.

In the wake of the Joplin and Tuscaloosa Tornado disasters of 2011, is the impact of WFO culture on performance still valid?

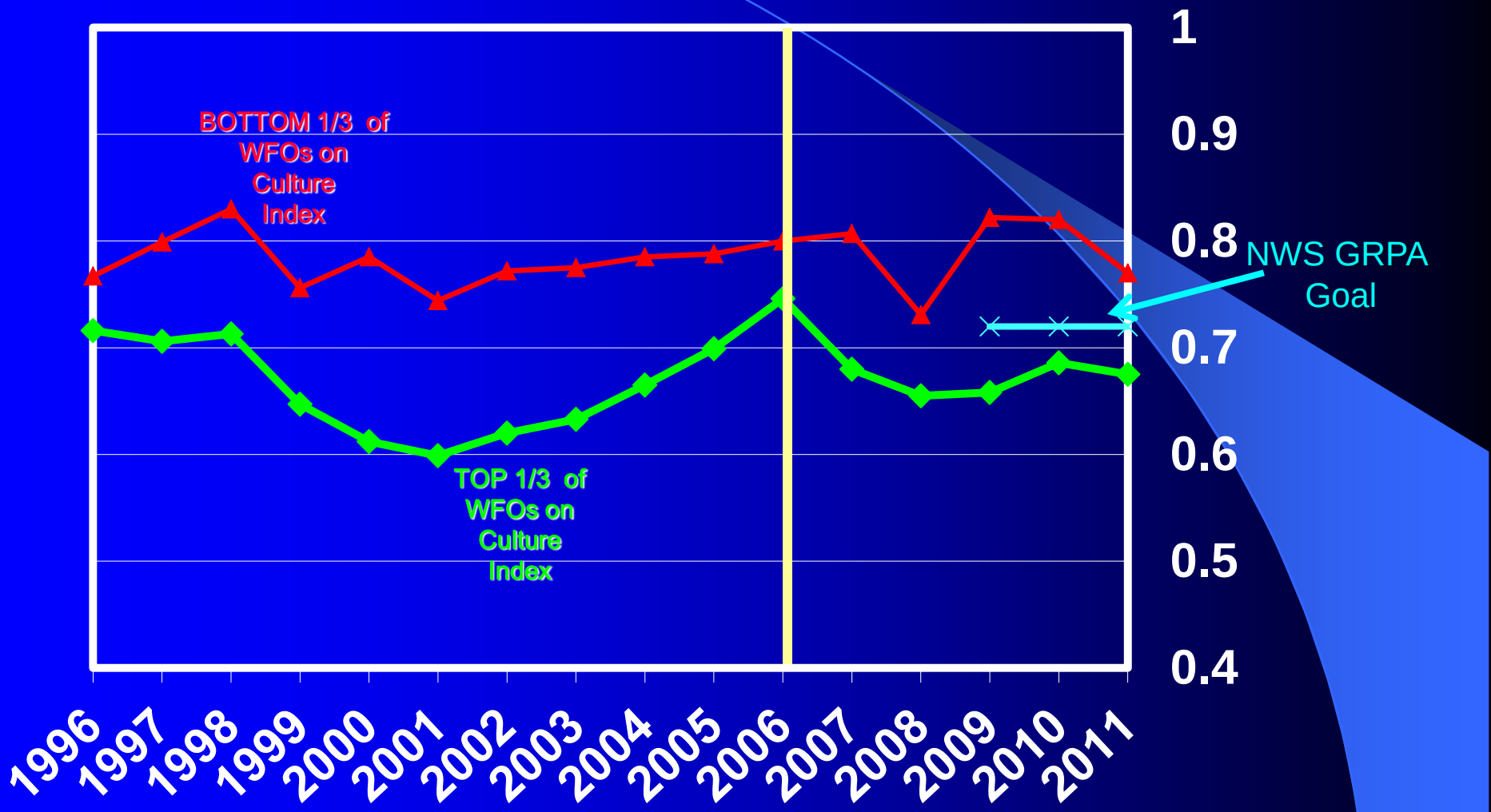
CSI


COUNTY-BASED WARNINGS
STORM-BASED WARNINGS
TOP 1/3 of WFOs on Culture Index
BOTTOM 1/3 of WFOs on Culture Index
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011

POD


TOP 1/3 of WFOs on Culture Index
BOTTOM 1/3 of WFOs on Culture Index
1
0.9
0.8
0.7
0.6
0.5
0.4
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011

FAR



16-year mean = 0.669

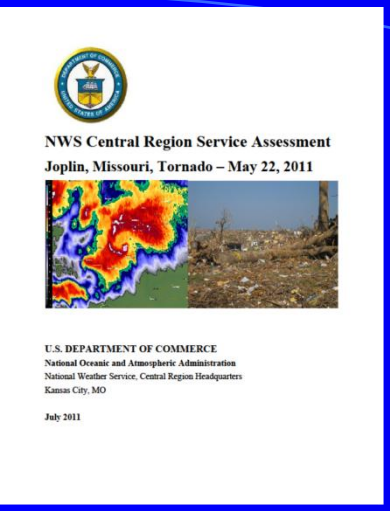
16-year mean = 0.784

NWS Central Region Service Assessment

Joplin, Missouri, Tornado – May 22, 2011

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service, Central Region Headquarters
Kansas City, MO

July 2011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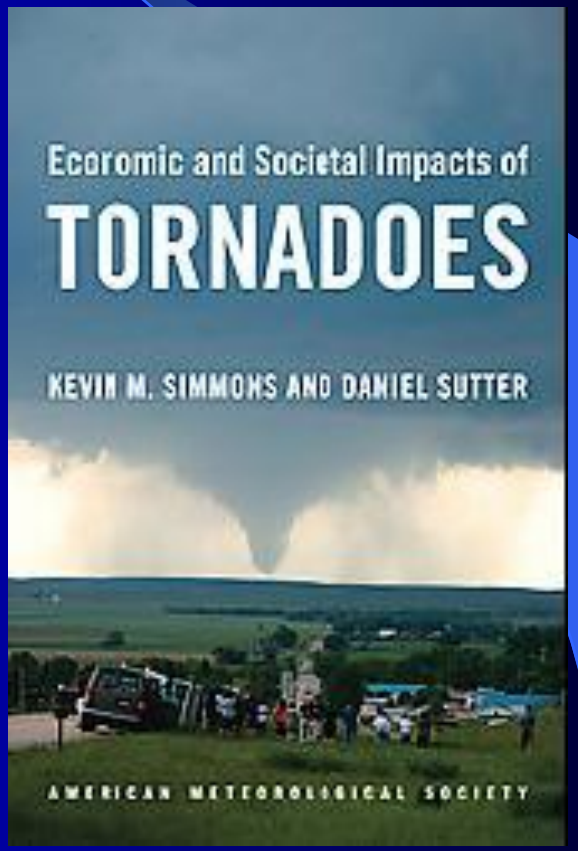
National Oceanic and Atmospheric Administration
National Weather Service, Central Region Headquarters
Kansas City, MO

July 2011

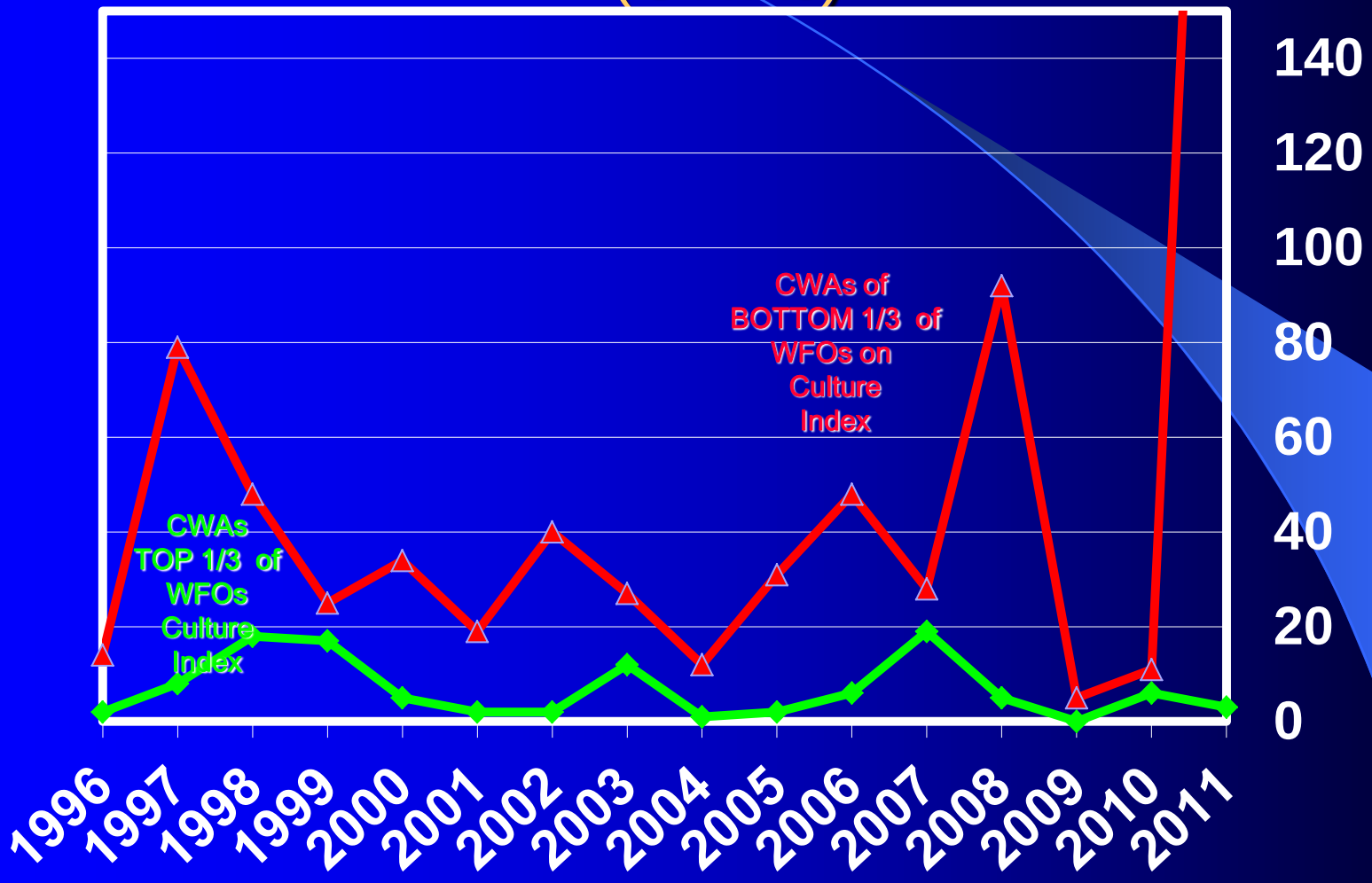
"While there are no guarantees that simply decreasing false alarms will significantly impact warning response behavior, the results of the Joplin residents interviews appear to indicate a relationship between perceived false alarms, degree of warning credibility, and complacency in warning response."

“We also found evidence of a false alarm effect, as a higher recent, local false alarm ratio (FAR) significantly increases fatalities and injuries.”

Simmons and Sutter (2011)

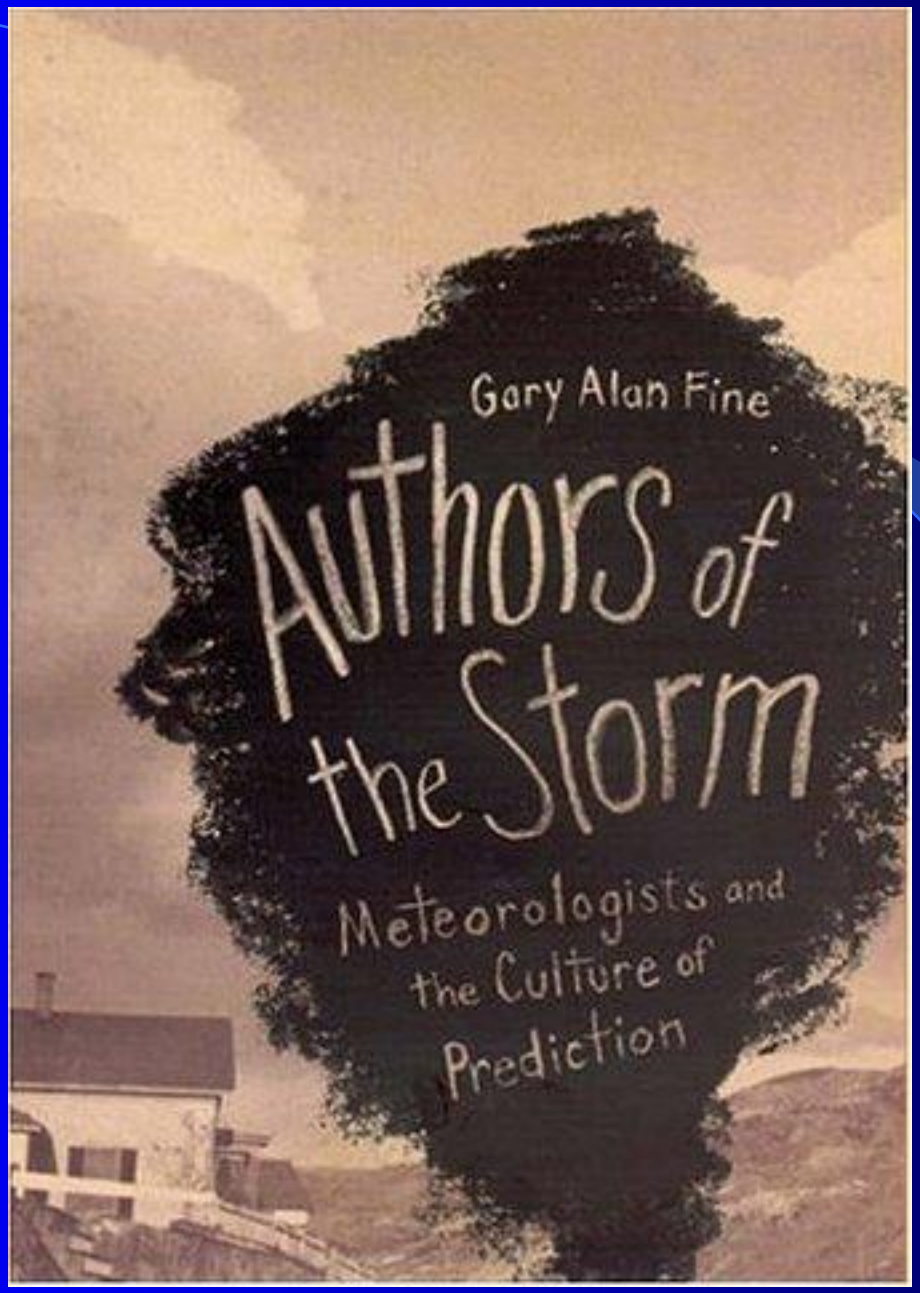


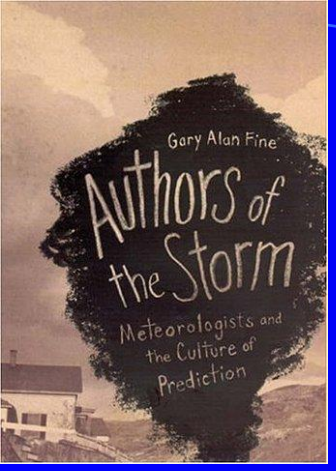
Annual Fatalities Occurring within WFO County-Warning Areas (CWAs)



16-year mean = 6.8

16-year mean = 53.6


Gary Alan Fine
Authors of the Storm
Meteorologists and the Culture of Prediction



"I argue that any orientation toward science and work is created by groups with their own shared pasts. Local conditions matter."

"They (group cultures) influence standards of occupational practice. Different cultures have distinct effects, even when tasks are ostensibly similar."

"Idiocultures can reverberate long after the original participants have departed."

Demographics of the WFO Culture Index

Region

Top 1/3
- CR: 56%
- SR: 32%
- ER: 6%
- WR: 6%

Bottom 1/3
- CR: 56%
- SR: 33%
- ER: 11%

Tornado Alley

Top 1/3
- Inside Tornado Alley: 50%
- Outside Tornado Alley: 50%

Bottom 1/3
- Inside Tornado Alley: 22%
- Outside Tornado Alley: 78%

Office History

Top 1/3
- Former WFSOs: 39%
- Former WSOs: 61%

Bottom 1/3
- Former WFSOs: 61%
- Former WSOs: 39%

Conclusions - Part II

- **A culture of high performance is enduring. In 2011, nine years after it was defined, the *Culture Index* continues to be a good predictor of tornado warning performance.**
- **The culture of high performance at the Top 1/3 WFOs in the study survived a major operations concept change (i.e. County-based to Storm-based tornado warnings). A culture of high performance is also a culture of change management.**

Conclusions - Part II (cont.)

- **The business case for non-technical "people" training in NWS is still valid.**
- **The Top 1/3 of 50 WFOs on the Culture Index have a lower mean annual tornado warning FAR and experience fewer tornado fatalities within their CWAs than the bottom 2/3 of WFOs**

  → Results are consistent with the findings of Simmons and Sutter (2011), the NWS Joplin Service Assessment (2011), and Fine (2007).

Key Questions

- **How can WFO culture be changed to improve performance?**

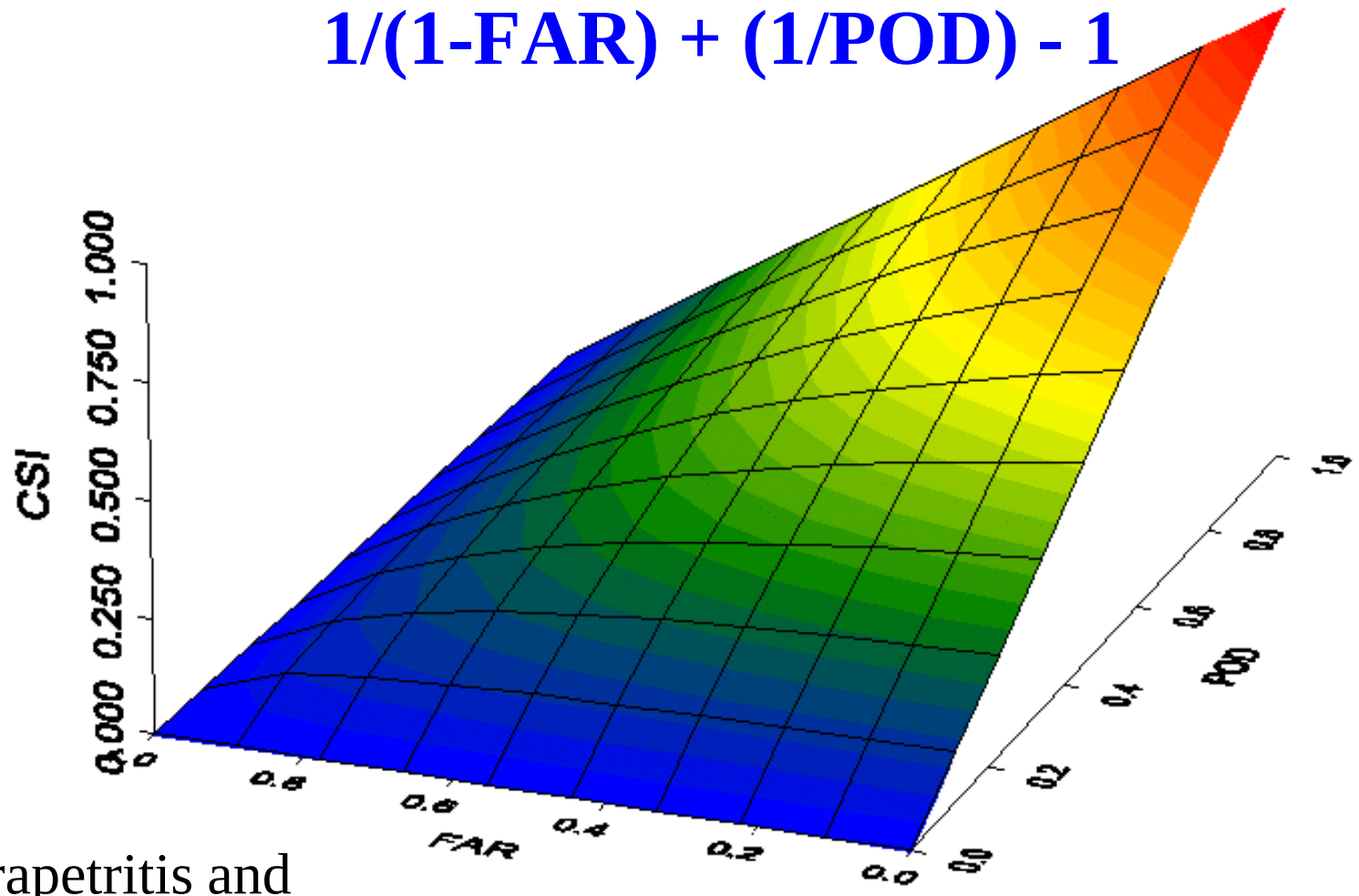
  → Case Study: Tom Kriehn and WFO MHX

- **What feedback loops exist between performance and WFO culture?**
- **What is the nature of the so-called false alarm effect?**

  → Critical Social Science Research Area

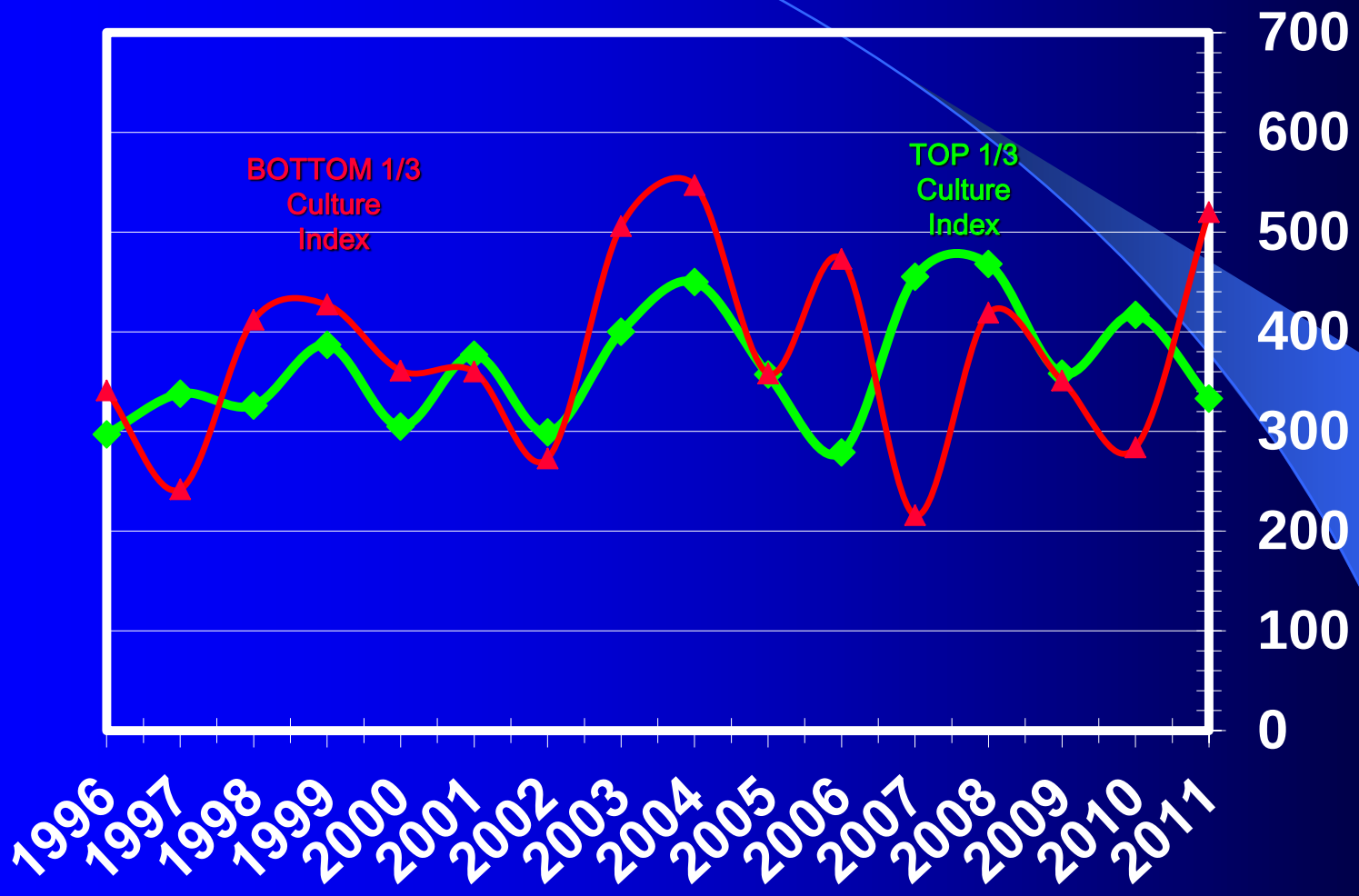
Back-up

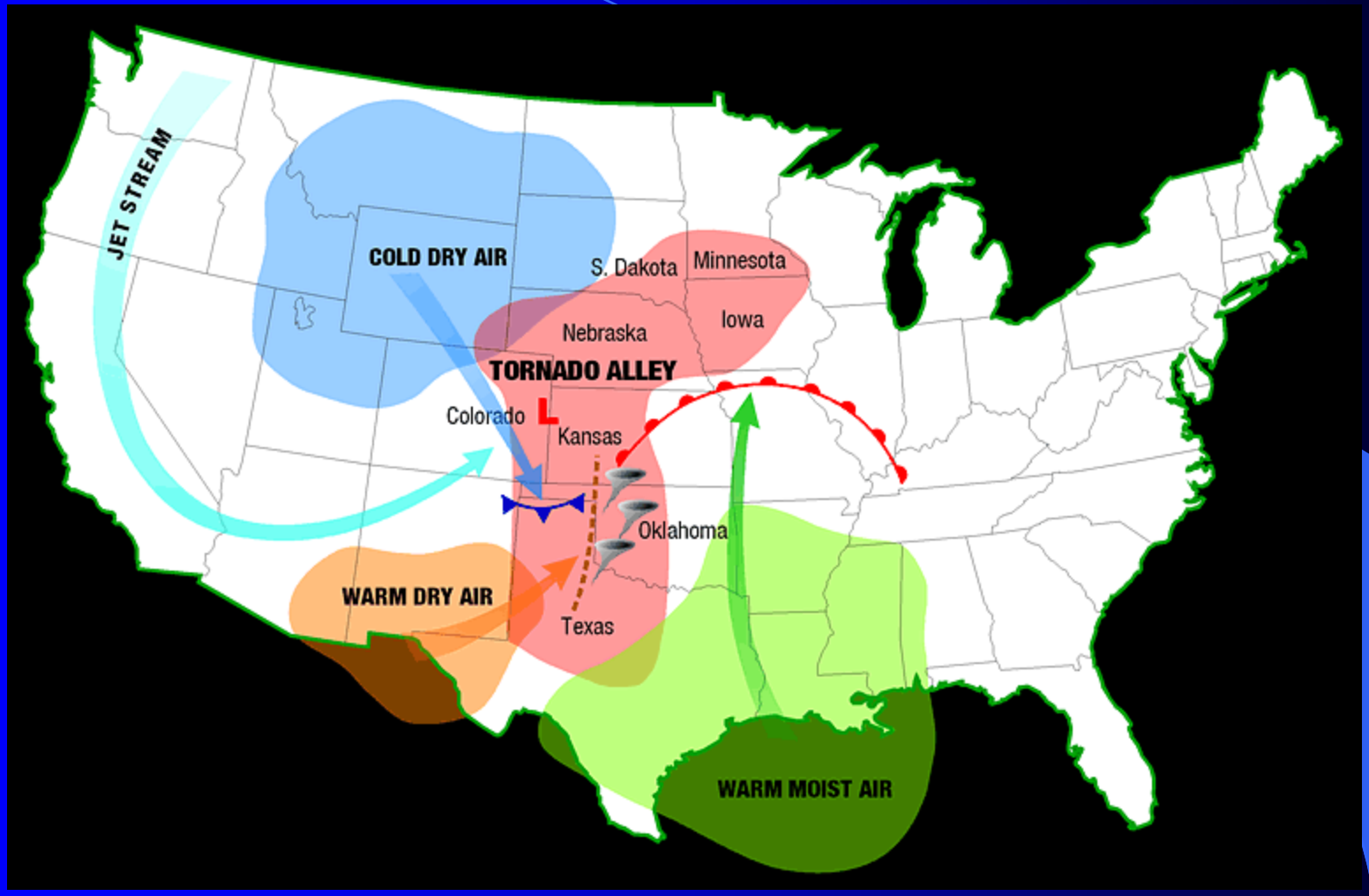
$$CSI = \frac{1}{1/(1-FAR) + (1/POD) - 1}$$



Gerapetritis and Pelissier

Annual Number of Tornado Events




JET STREAM
COLD DRY AIR
S. Dakota
Minnesota
Iowa
Nebraska
TORNADO ALLEY
Colorado
L
Kansas
Oklahoma
WARM DRY AIR
Texas
WARM MOIST AIR