

Users, Uses, and Value of Landsat Imagery in the United States

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Survey Study Objectives

To better understand the uses, users, and value of moderate resolution imagery

- Identify and classify users
- Understand how and why imagery is being used
- Evaluate effects of “no cost” data policy
- Qualitatively and quantitatively measure societal benefits and value of this imagery

Challenges

- How do you study an unknown population or resource?
 - Wildlife—observation, mark/recapture, quad counts
 - Geography—surveying, mapping, modeling
 - People—census, birth records, vehicle registrations



Edrengeyn Nuruu, Mongolia
(<http://eros.usgs.gov/imagegallery/index.php>)

Study Components

- Phase I: User Assessment
 - ID potential users via online search
 - Refine through *snowball sampling*
 - Summer 2008
- Phase II: Online User Survey
 - Fall 2009



Kamchatka Peninsula

(<http://eros.usgs.gov/imagegallery/index.php>)

Response Rates

- User Assessment

Valid Emails	# Agreeing to Participate	Users of MRI	Not Users	Don't Know
~22,000	4,753	~80%	~16%	~4%

- Survey

Total Sent	# Responded	Undeliverables	Response Rate
4,753	2,523	19	53%

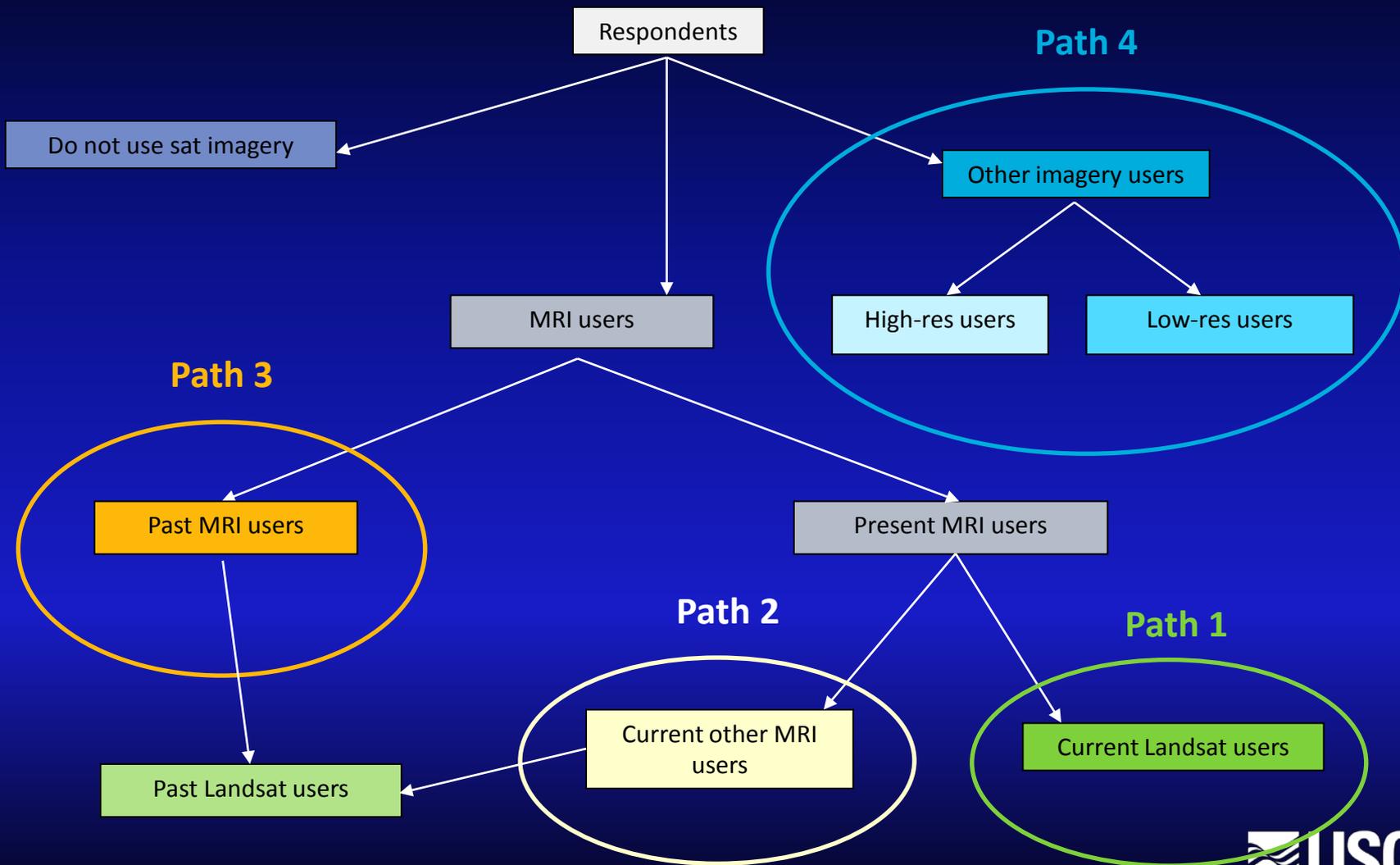
Overview of Results

- Emphasis on Landsat users
- Descriptives & comparisons
 - User profile
 - Uses
- Effects of Landsat imagery becoming available at no cost
- Value of Landsat imagery

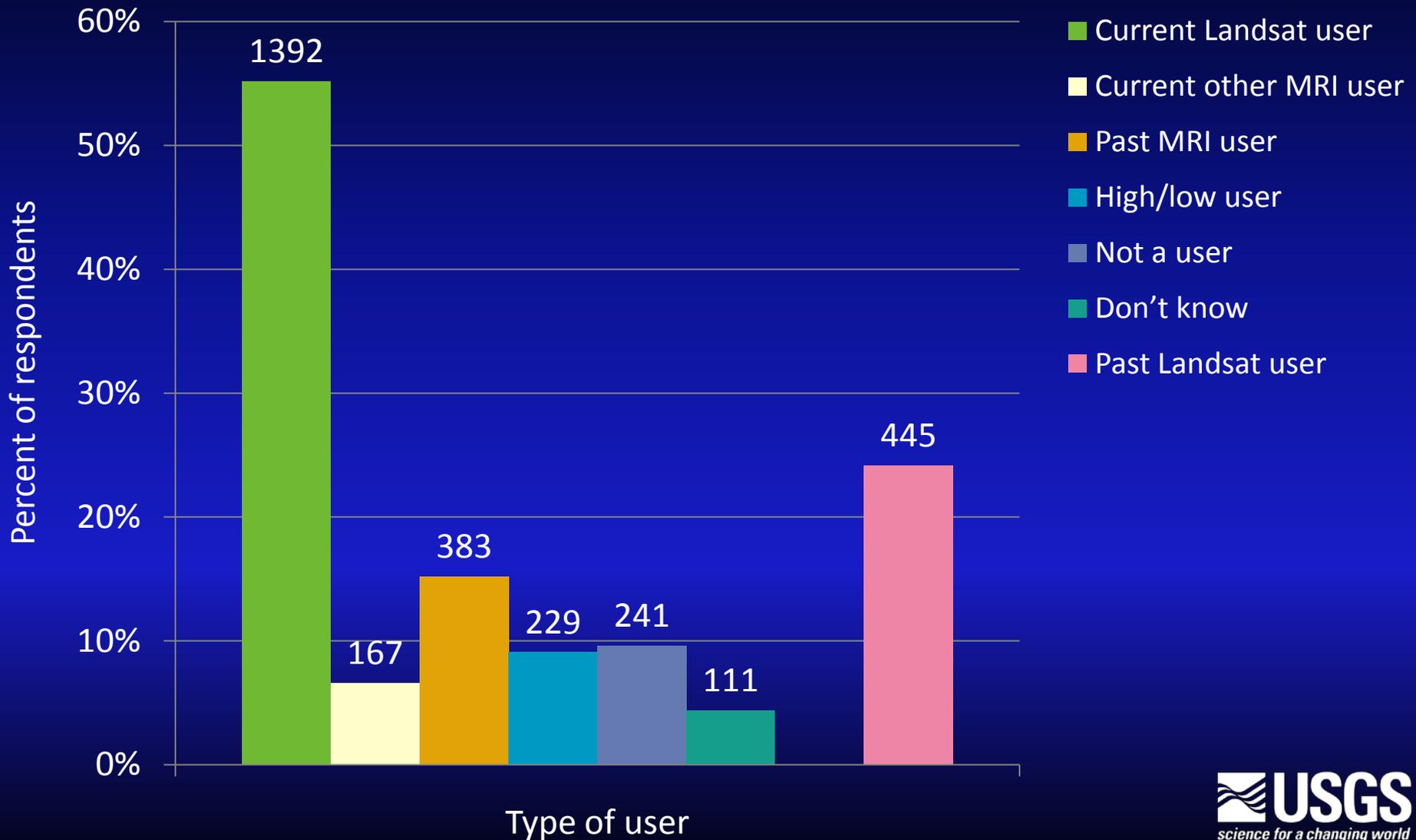


Richat Structure, Maur Adrar Desert, Mauritania
(<http://eros.usgs.gov/imagegallery/index.php>)

Who Did We Sample?

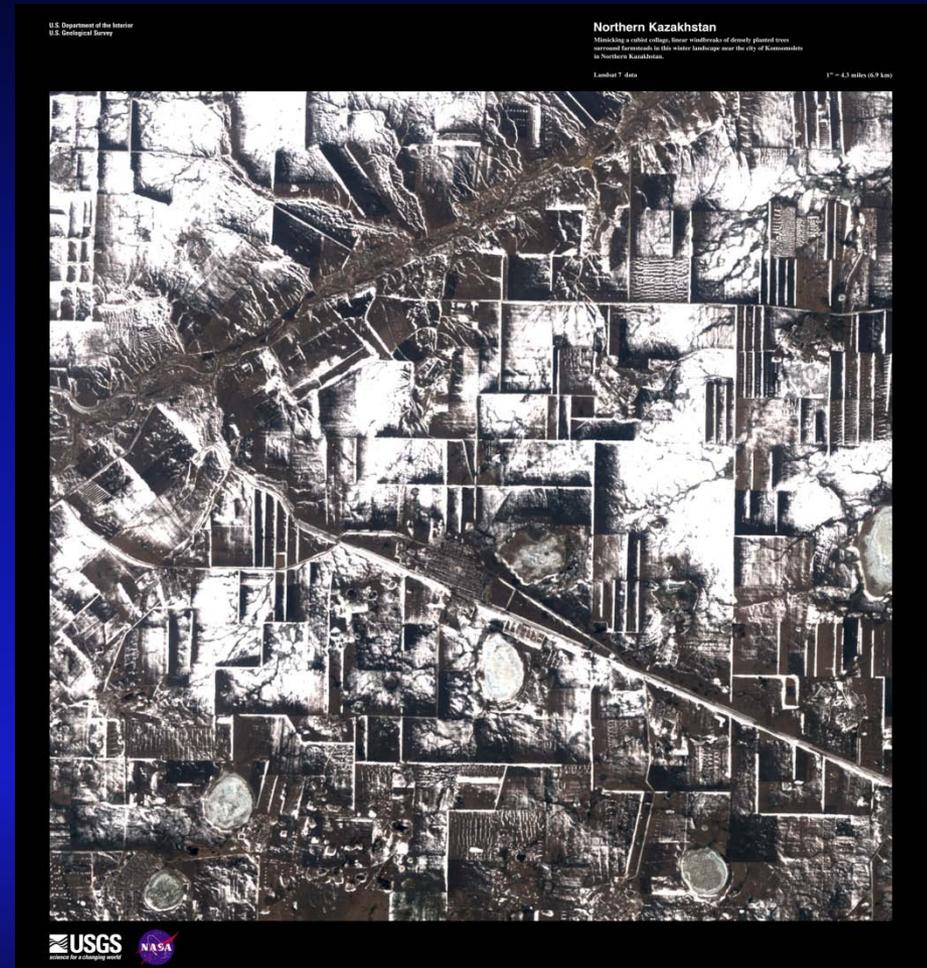


The Sample



User Profile

- Education
- Gender
- Age
- Ethnicity
- Race
- Membership in professional organizations
- Sector

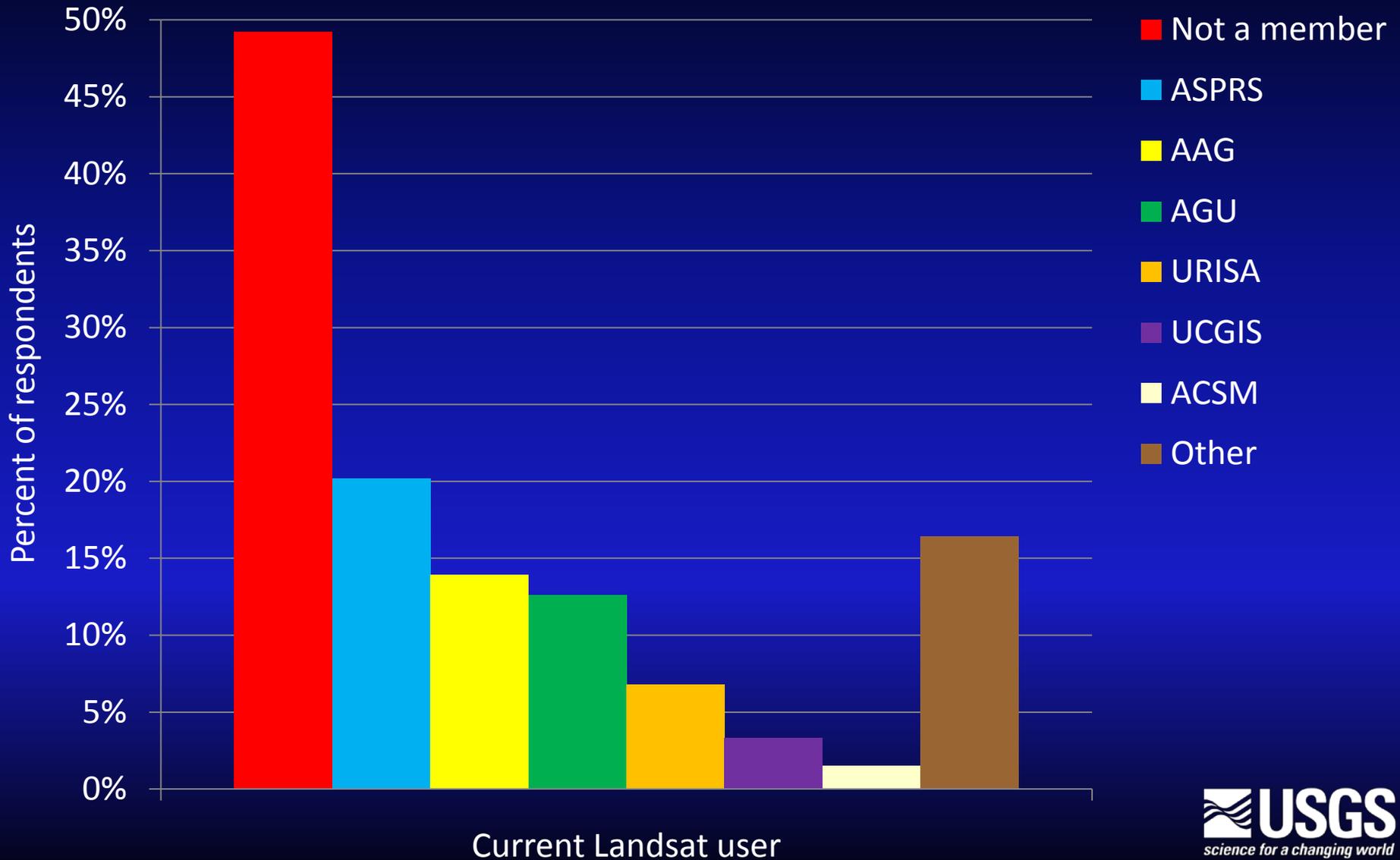


Farms, Komsomelets, Northern Kazakhstan
(<http://eros.usgs.gov/imagegallery/index.php>)

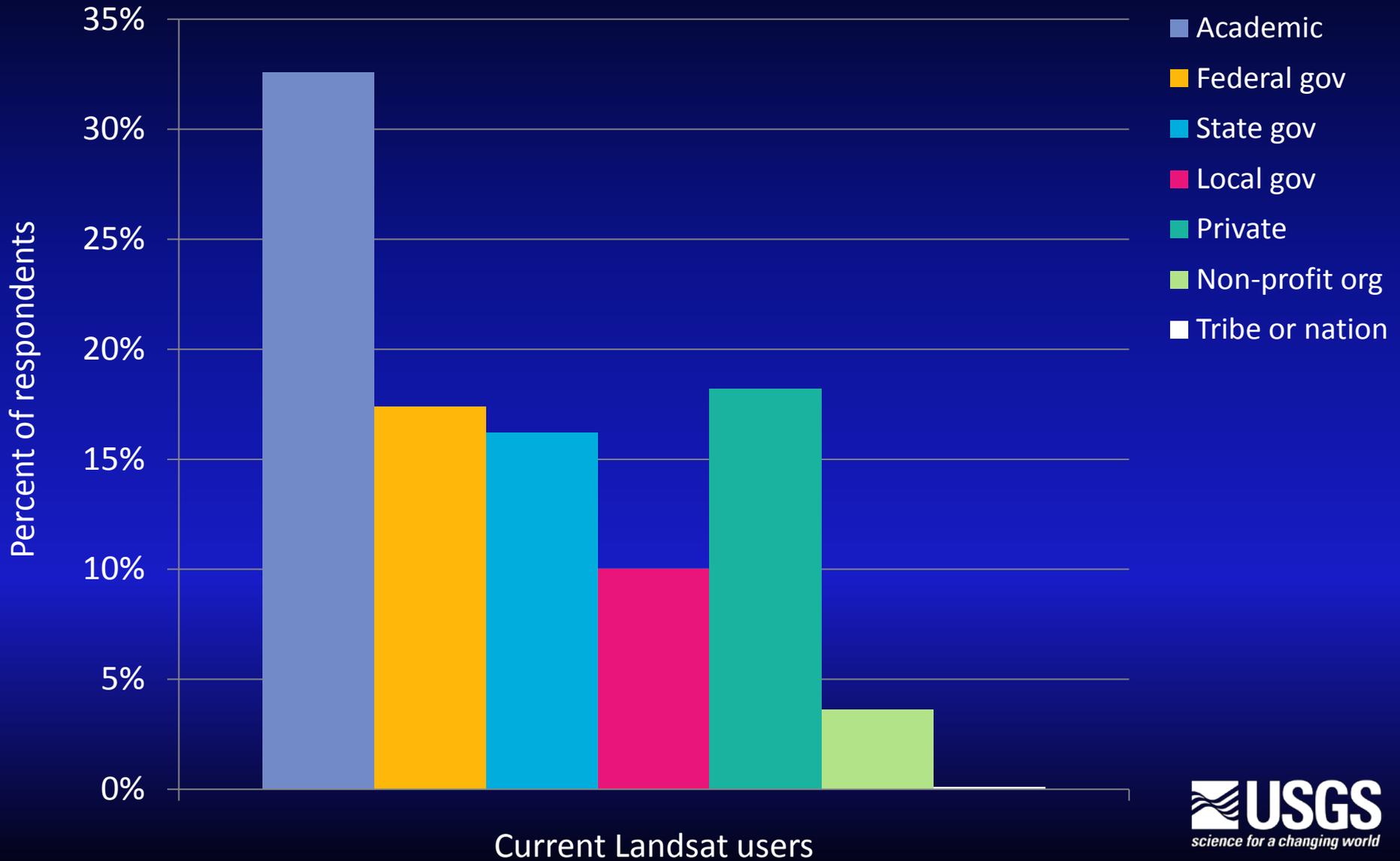
Demographics

Demographic	Current Landsat users
Predominant sector	Academic institution
Median level of education	Masters degree
Member of RS/GIS org	51%
Gender	76% Male
Mean age	47
Ethnicity	3% Hispanic or Latino
Race	91% White/Caucasian

Membership in RS/GIS Org



Sector



MRI Used in Past Year

Imagery	Current Landsat user	Academic institution	Federal gov	State gov	Local gov	Private business	Non-profit org	Other MRI user
Landsat	54%	65%	57%	49%	31%	48%	57%	NA
Terra	11%	15%	12%	7%	5%	10%	11%	10%
SPOT	8%	7%	8%	9%	8%	7%	9%	7%
Resourcesat	3%	2%	7%	2%	2%	3%	4%	2%
ALOS	1%	<1%	1%	1%	<1%	2%	2%	1%
CBERS	<1%	<1%	1%	<1%	<1%	1%	1%	<1%
Other	6%	5%	6%	5%	10%	8%	3%	26%
Unknown	16%	5%	8%	26%	43%	21%	13%	53%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Uses of Landsat Imagery

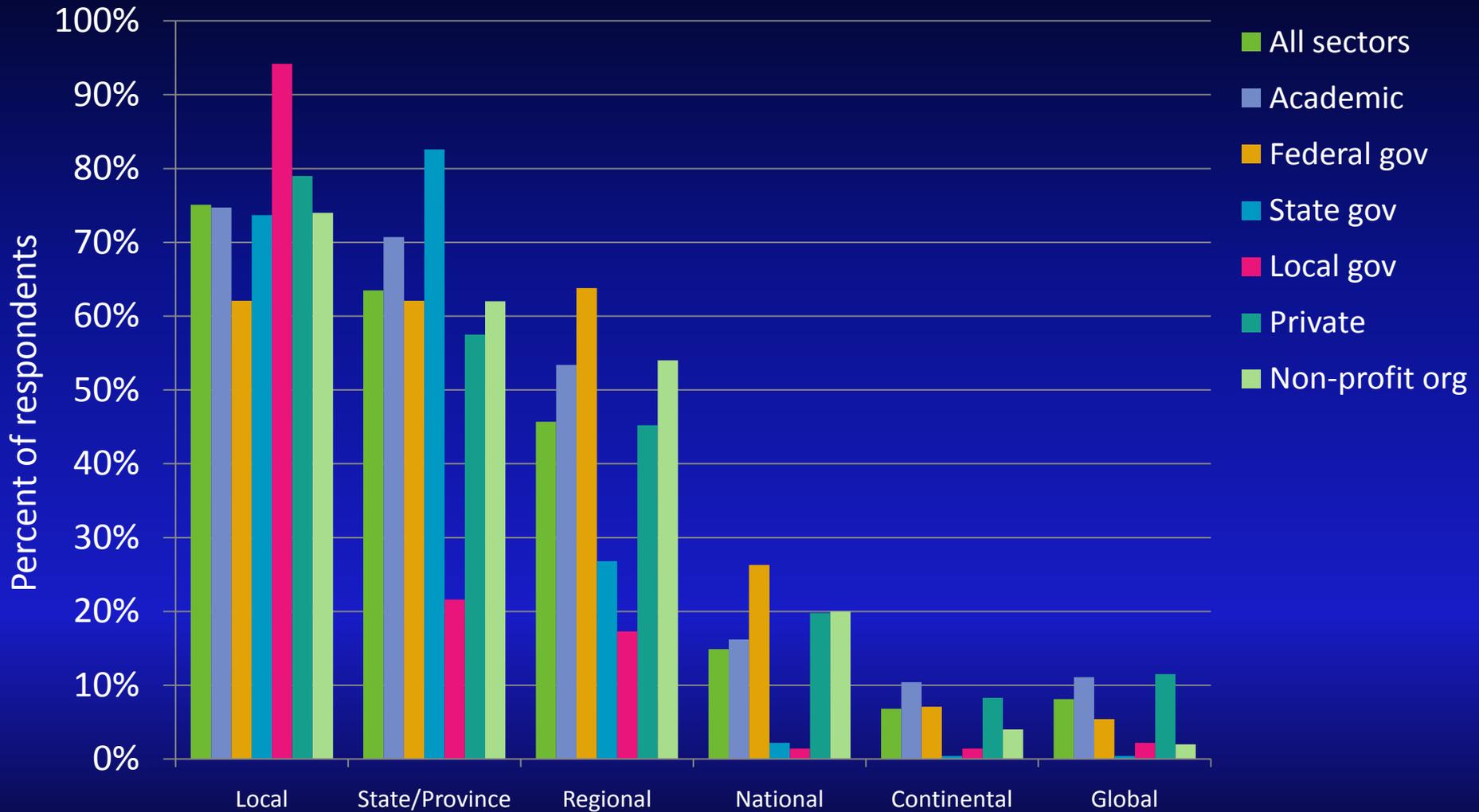
- Scales
- Locations
- Applications
 - Primary
 - Secondary
- % work using Landsat
- How using MRI?



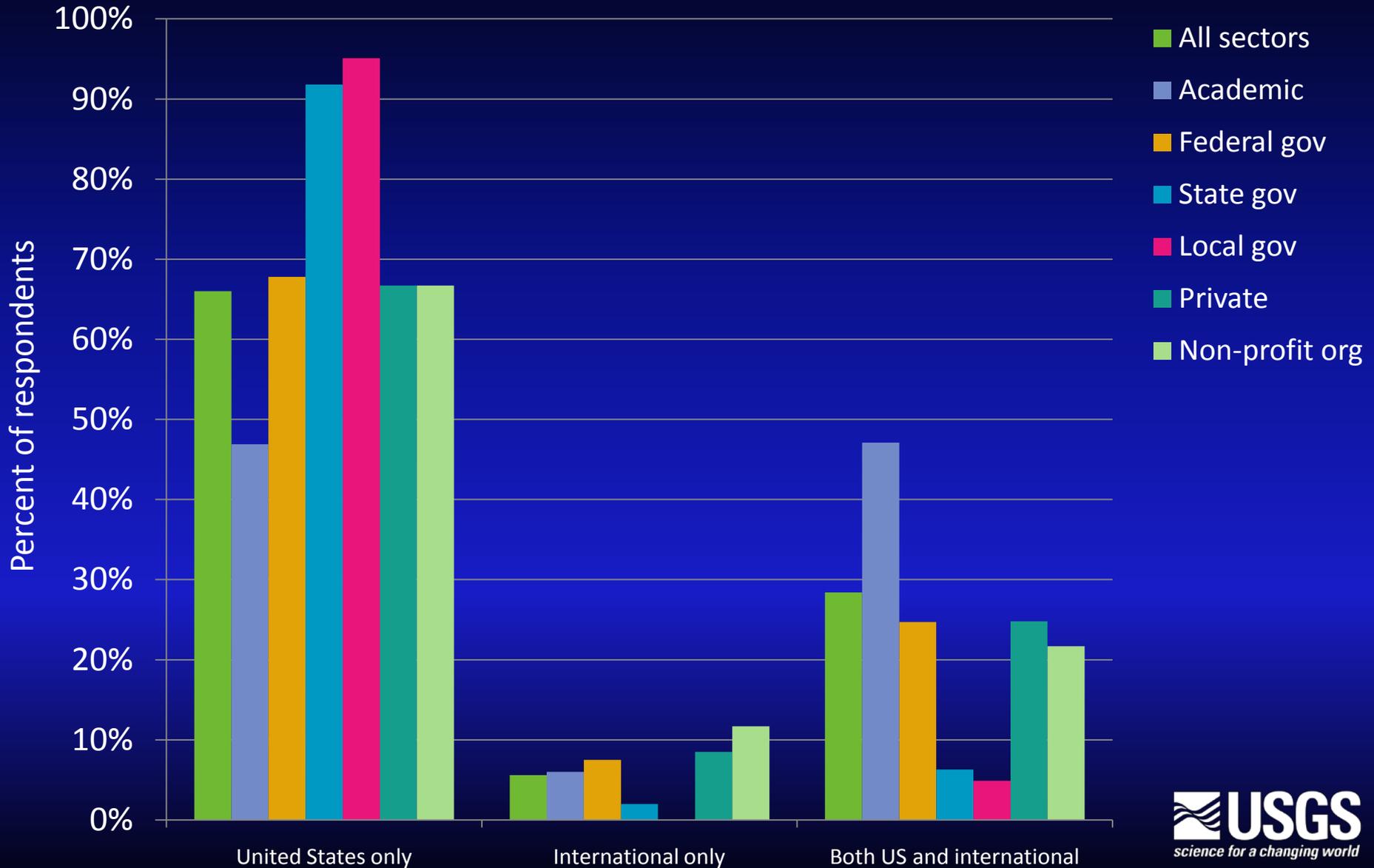
Von Karman Vortices

<http://eros.usgs.gov/imagegallery/index.php/>

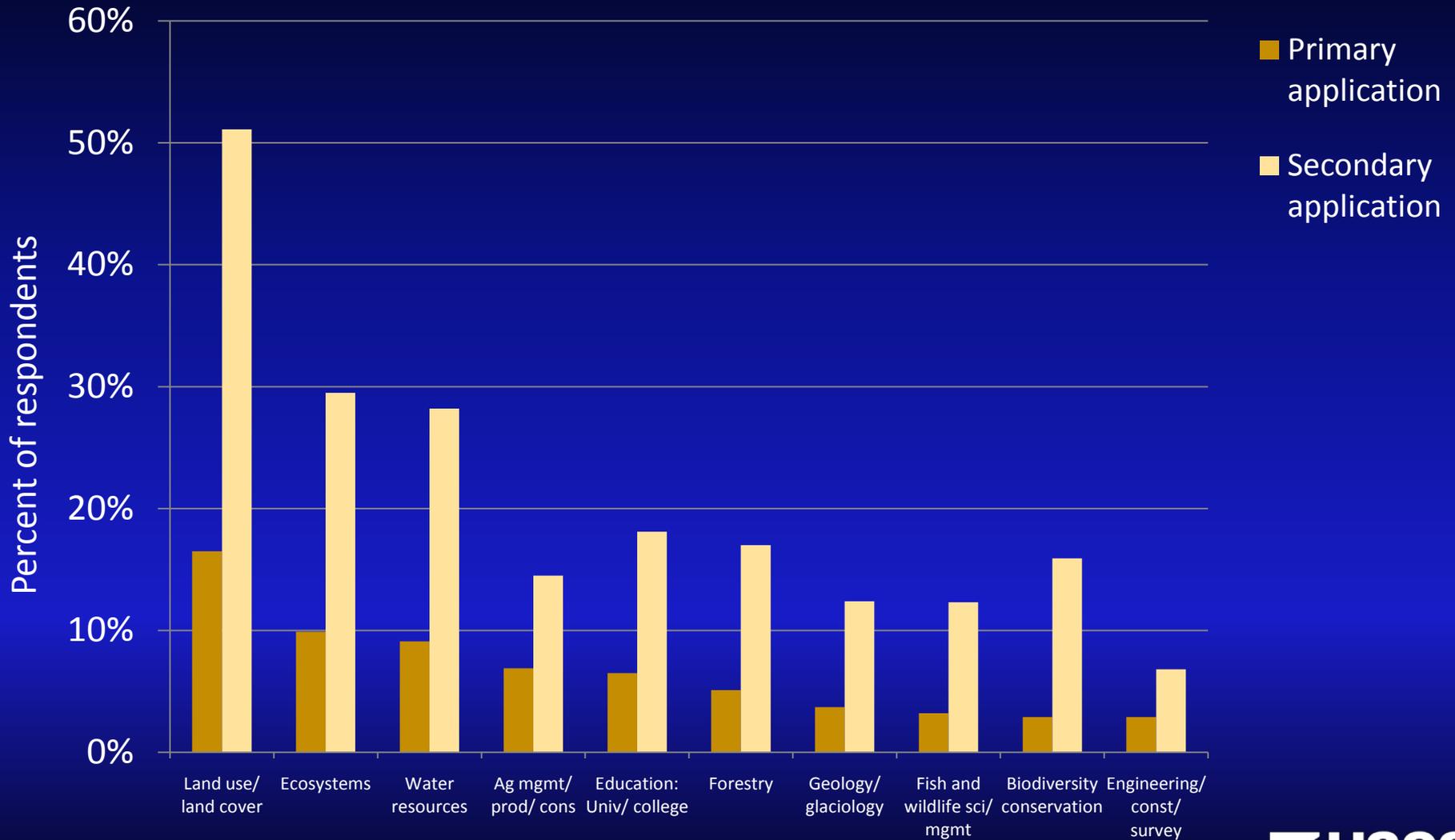
Scales of Projects



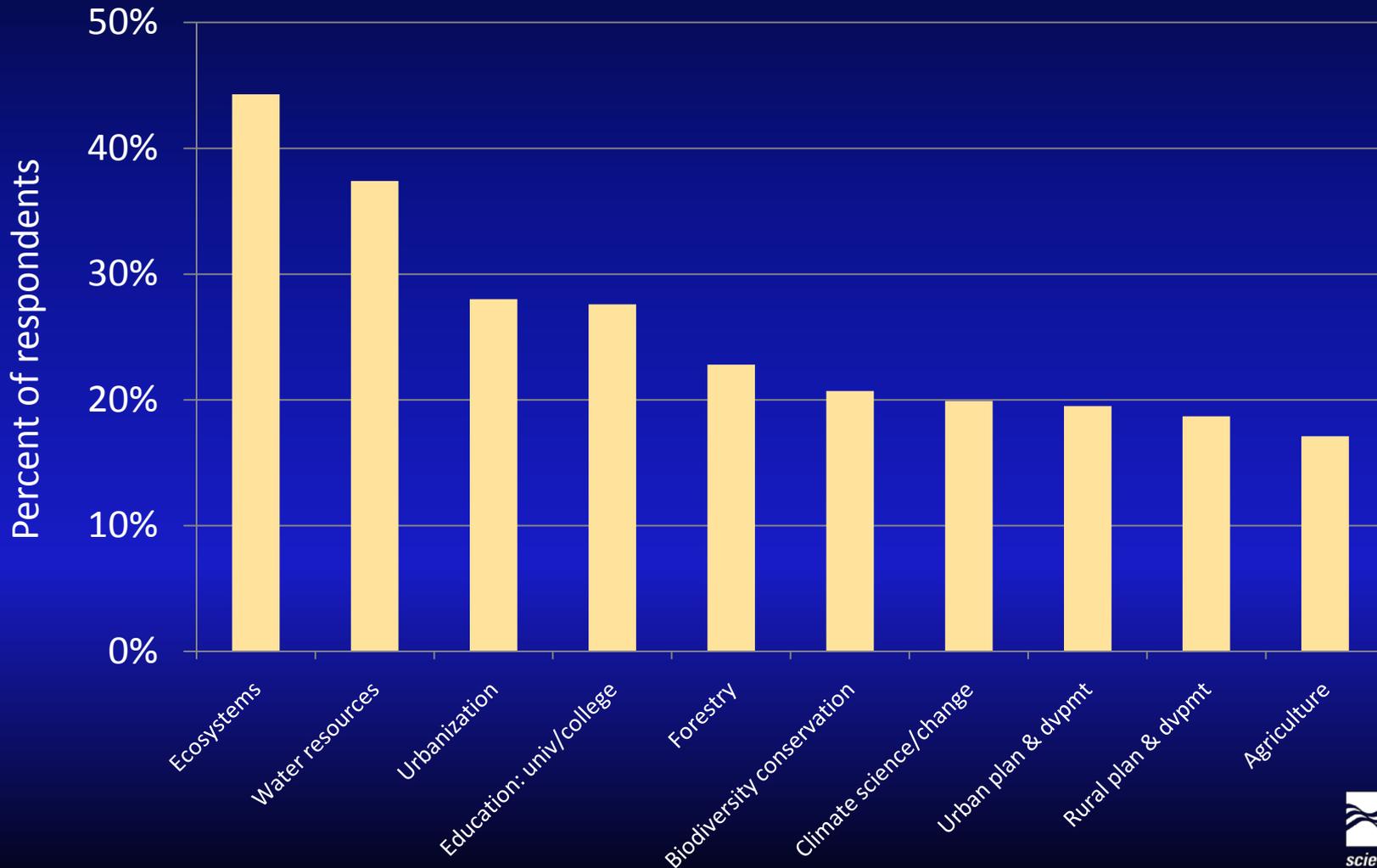
Locations of Projects



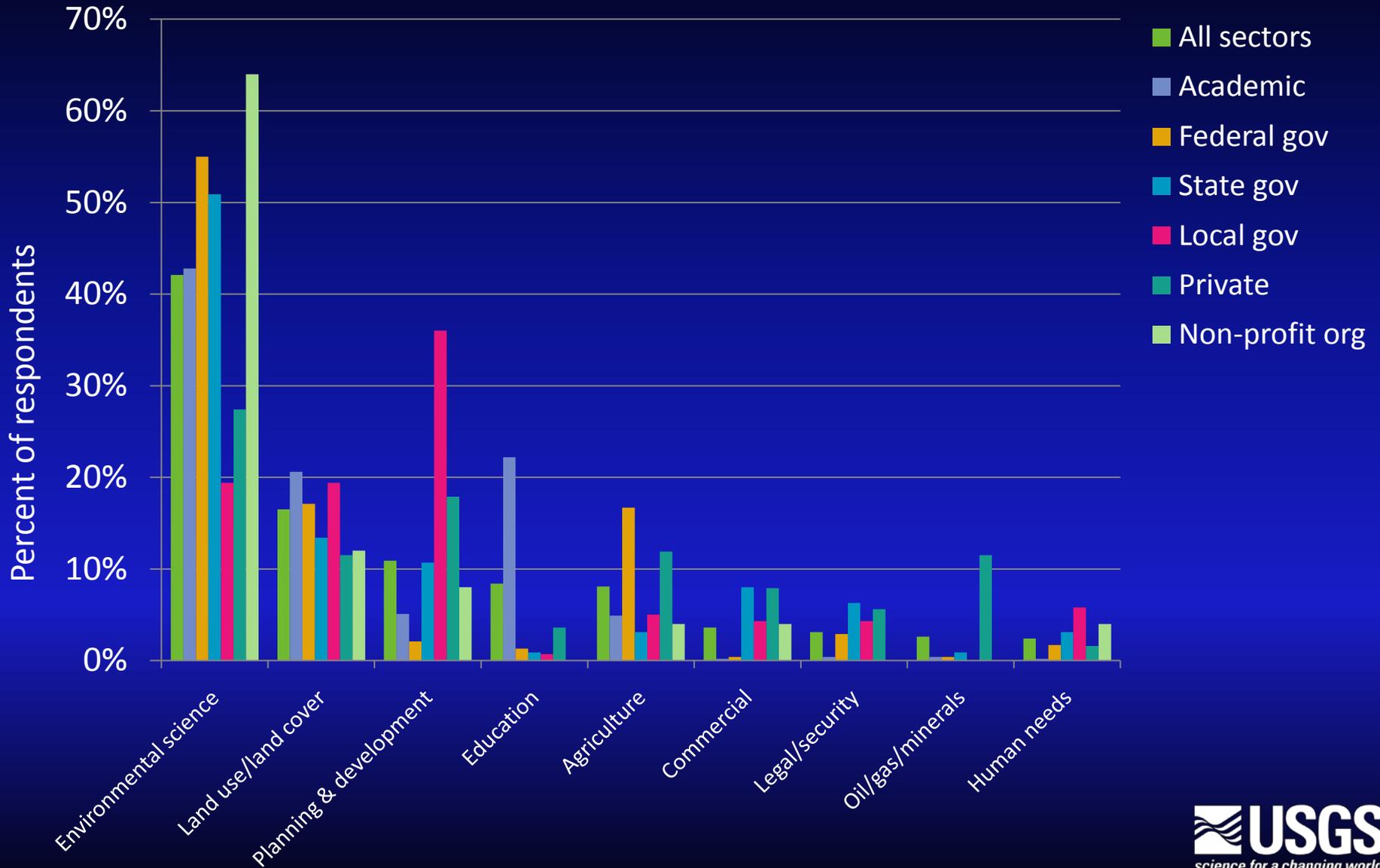
Application Areas



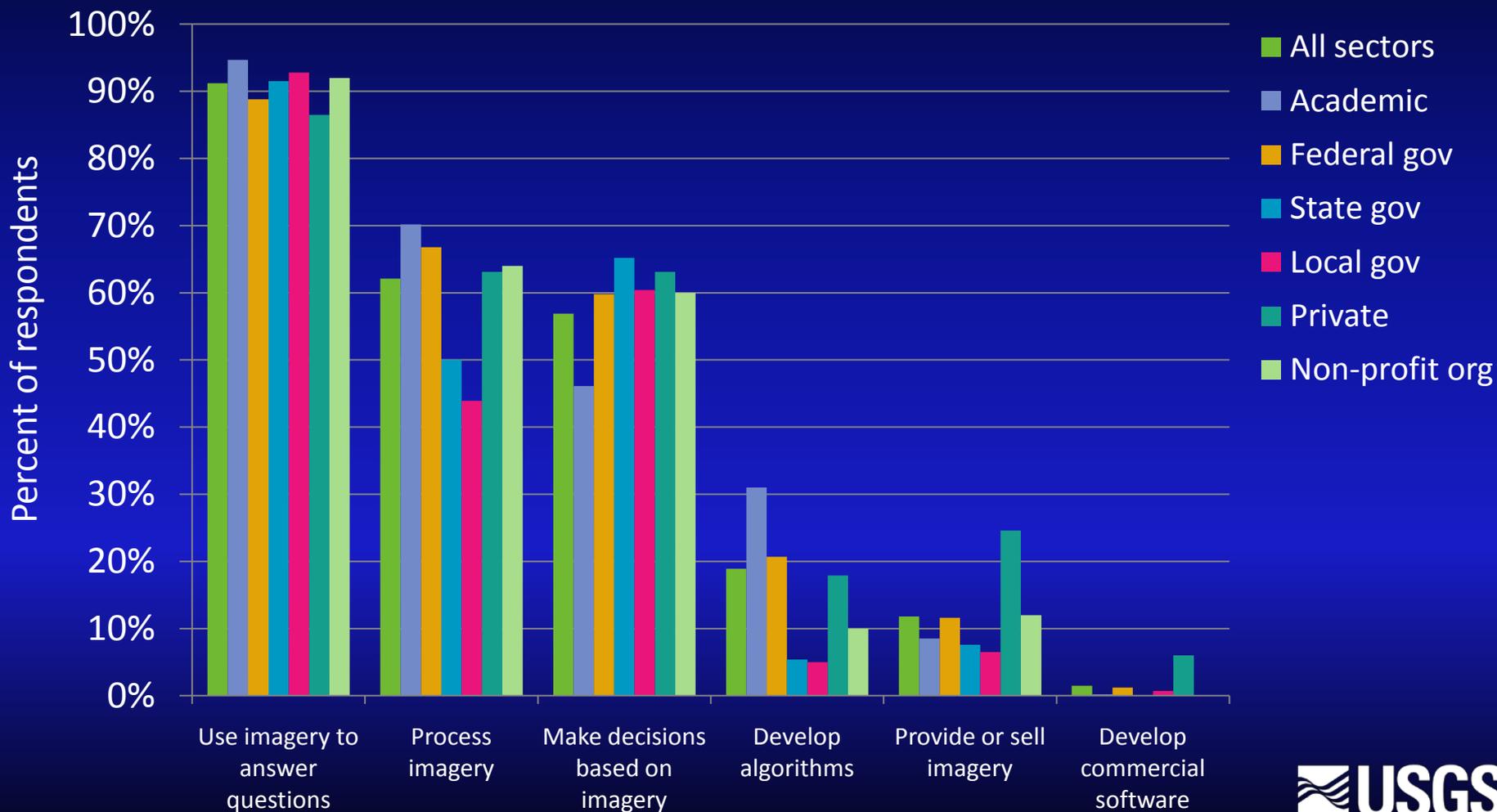
Land Use/Land Cover: Secondary Applications



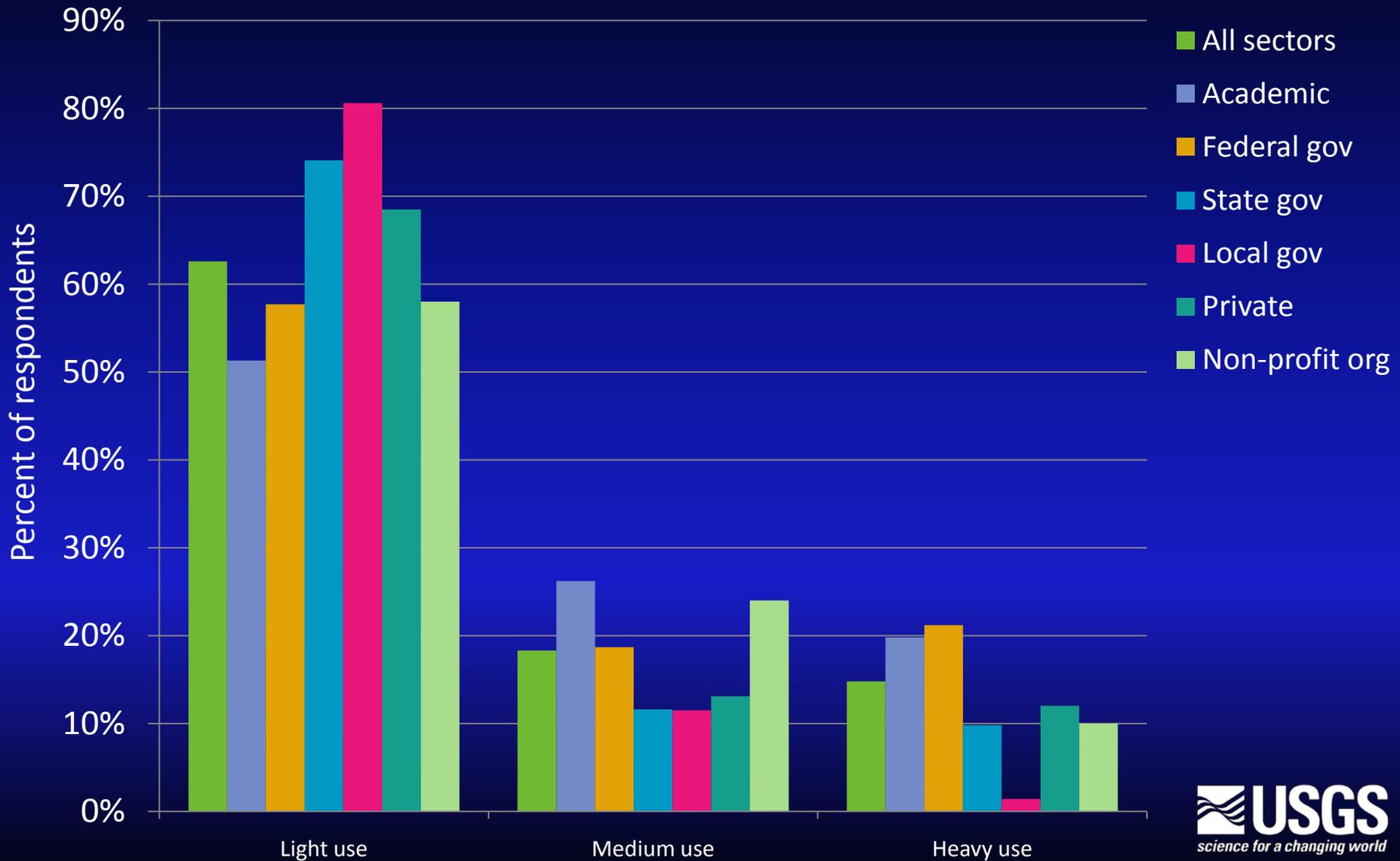
Primary Applications



Which describes your work with moderate-resolution imagery?



Level of Landsat Use in Work



“Local Users”

- Working in local or state gov applying imagery in projects at local scales in the U.S.
 - More likely to be applying imagery in planning & development and transportation
 - Less likely to process imagery, provide/sell imagery, or develop algorithms
 - More likely to be a light Landsat user



Parana River Delta, Argentina
(<http://eros.usgs.gov/imagegallery/index.php/>)

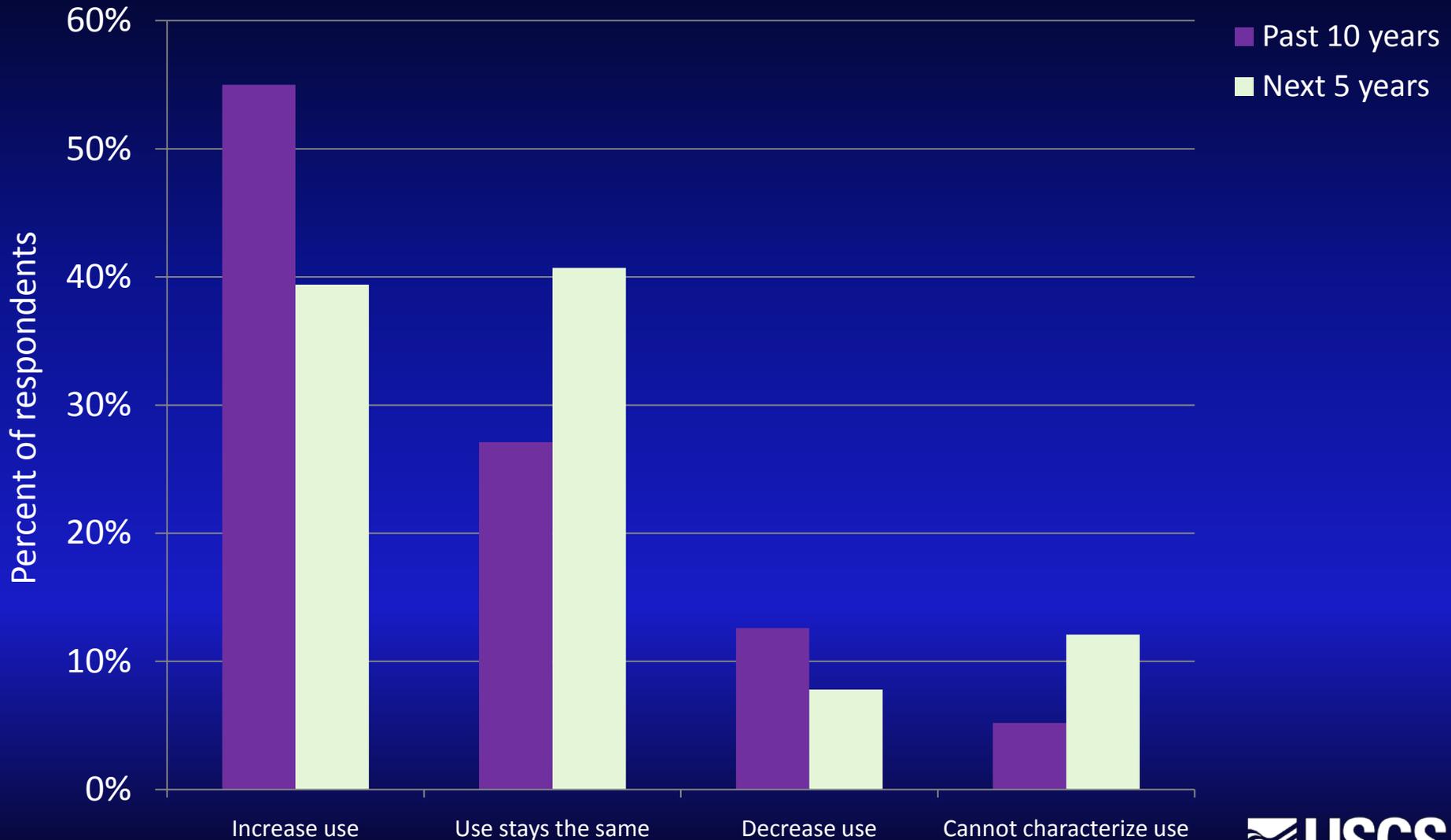
Changes in Landsat Use

- Current Landsat users
 - Past 10 years
 - Next 5 years
- Non-Landsat users
 - Likelihood of use in the future

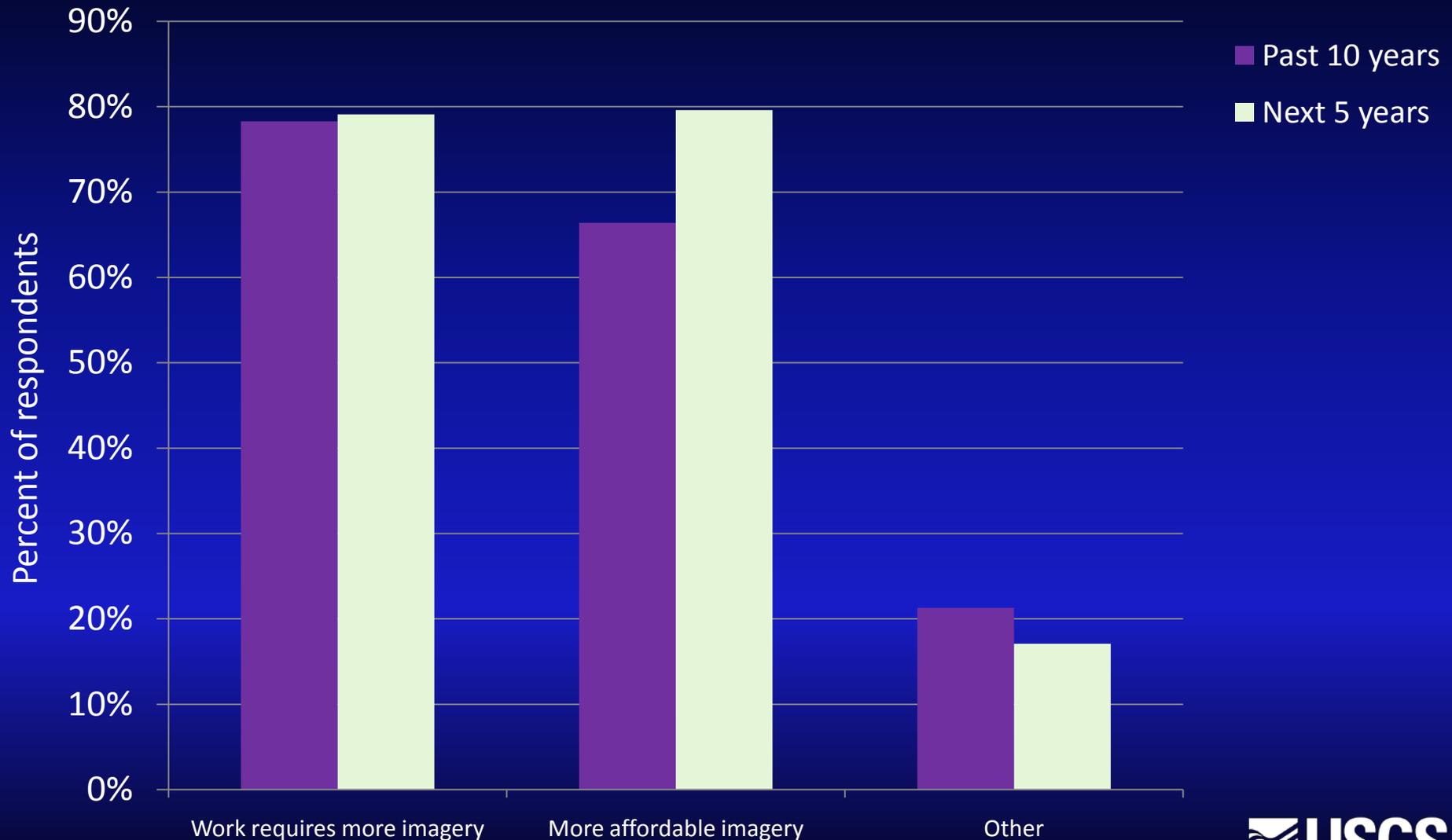


Ganges River Delta
(<http://eros.usgs.gov/imagegallery/index.php/>)

Changes in Landsat Use Over Time

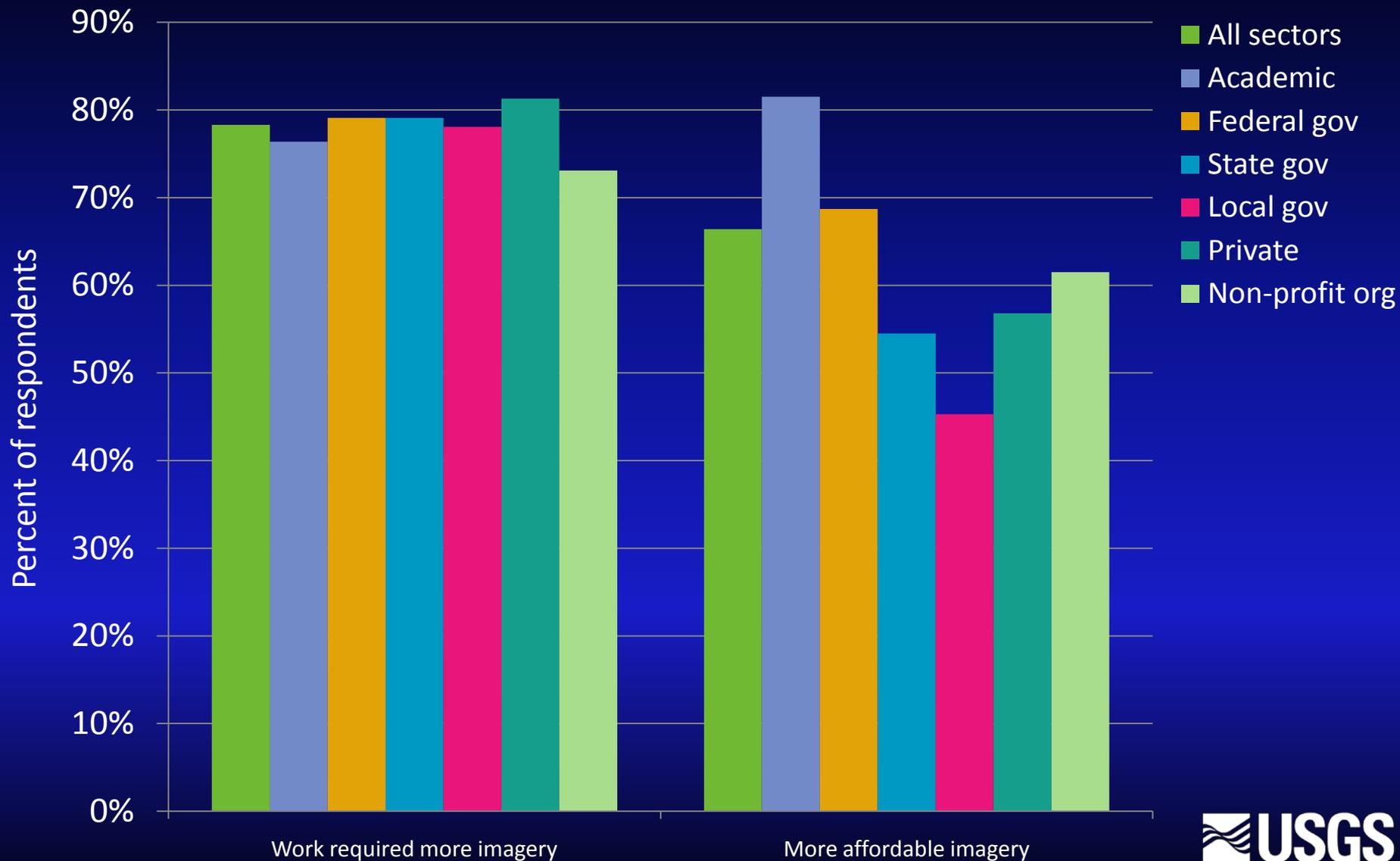


Reasons for Increasing Use

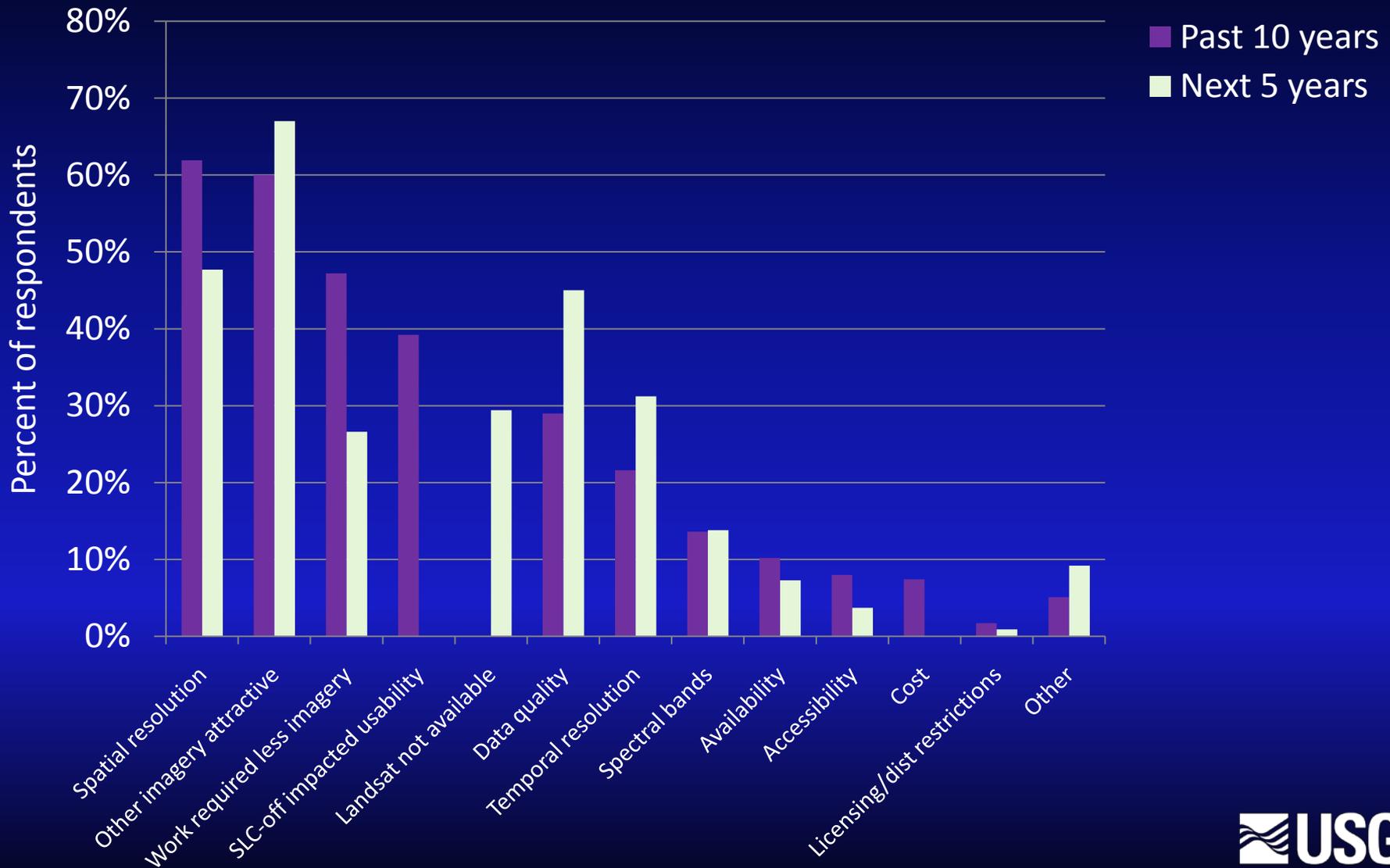


“Increase is dependent on the assumption of availability of a new Landsat sensor”

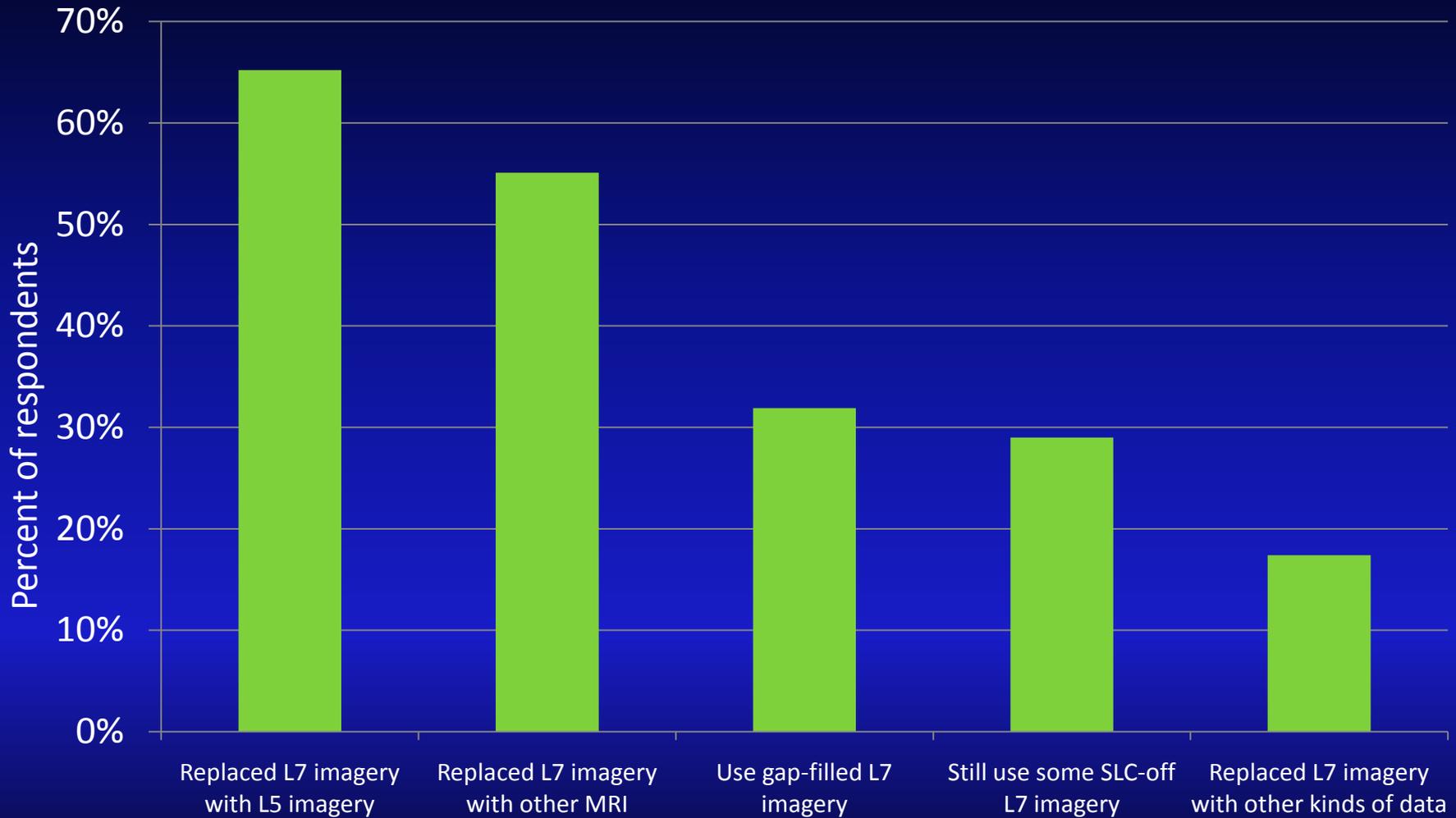
Reasons for Increasing Use in Past 10 Years



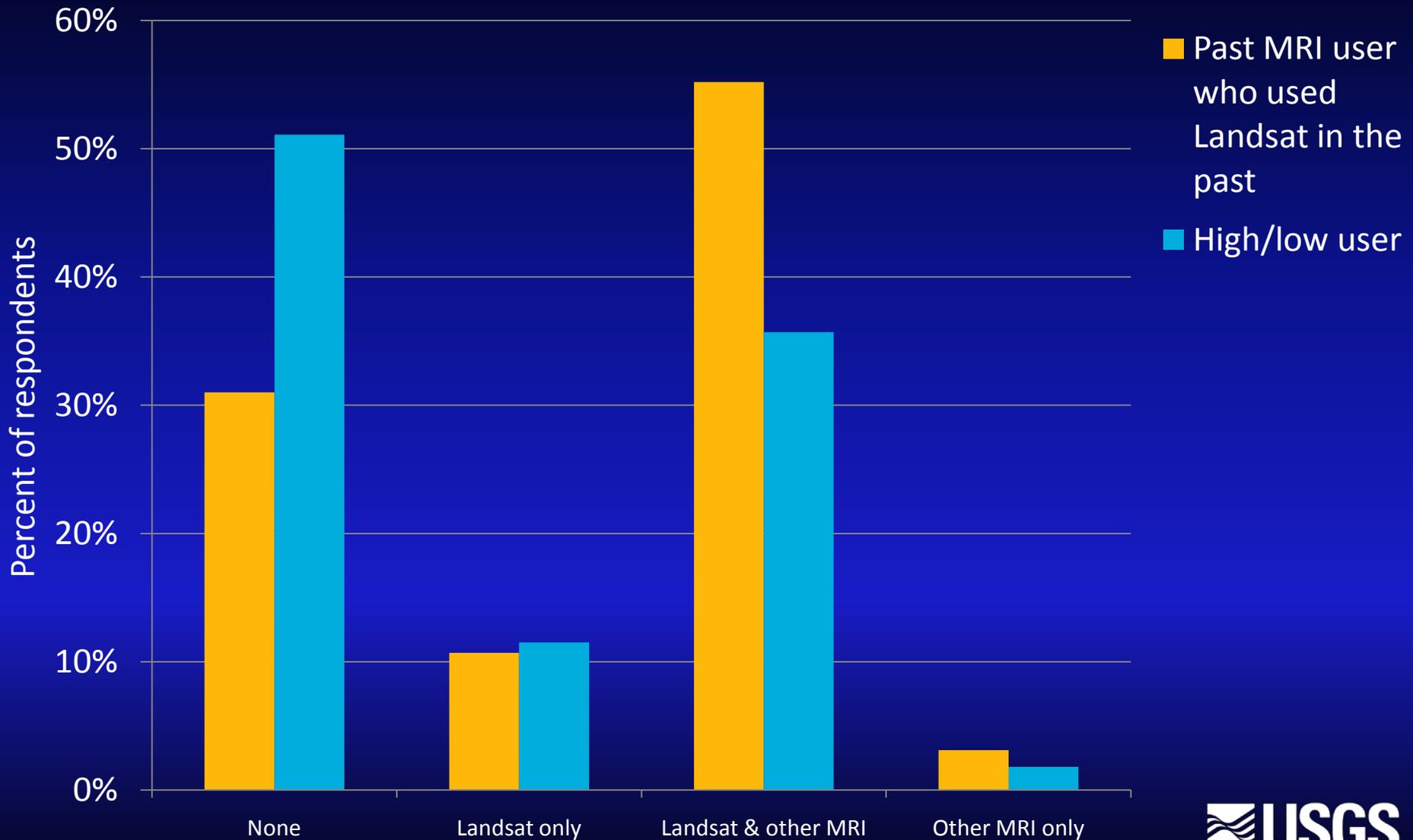
Reasons for Decreasing Use



Responses to SLC-Off



Future MRI Use Among Non-Landsat Users



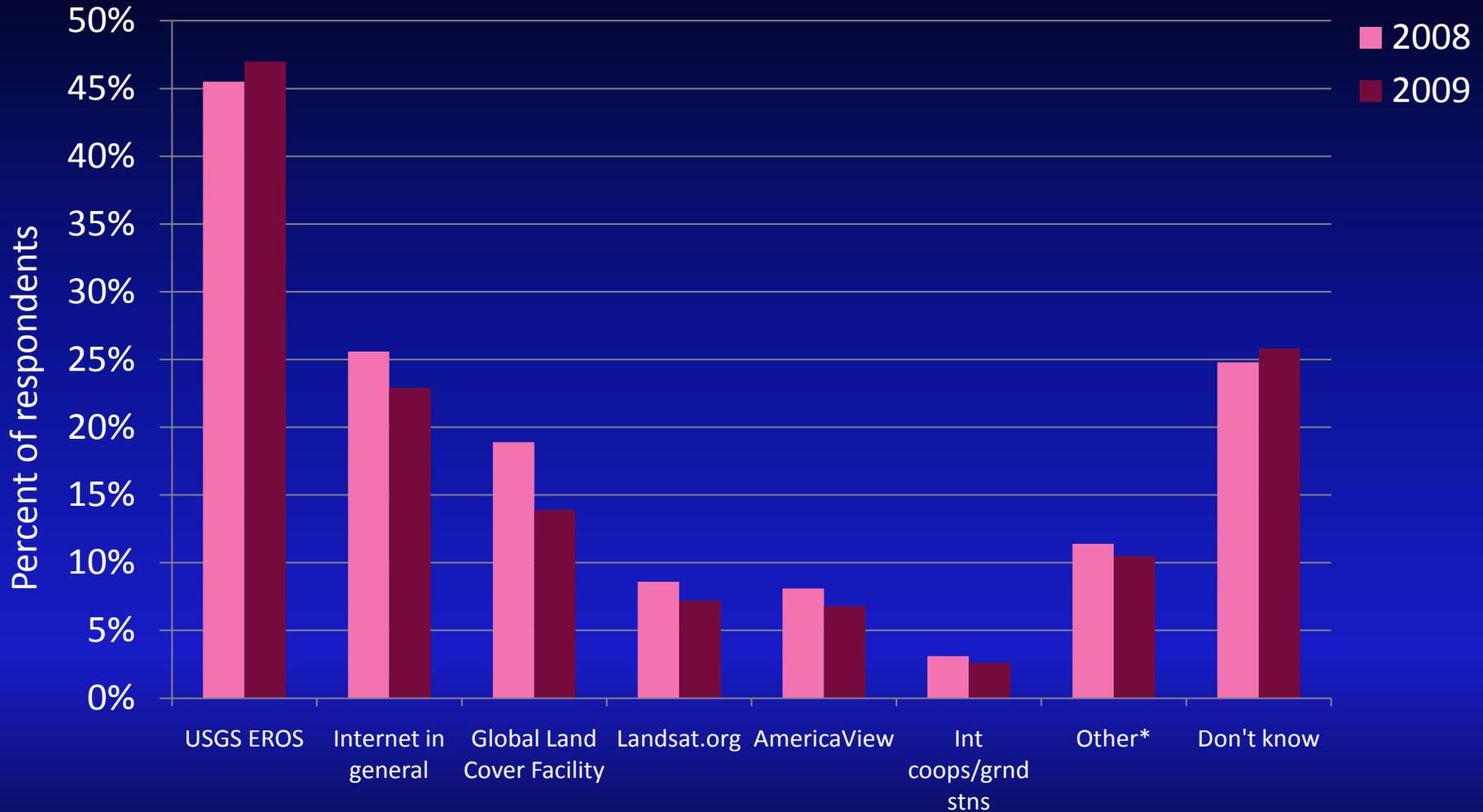
Effects of “No Cost” Imagery

- Before and after
 - Where users acquire imagery
 - Number of scenes
 - \$ dollars spent (or saved)



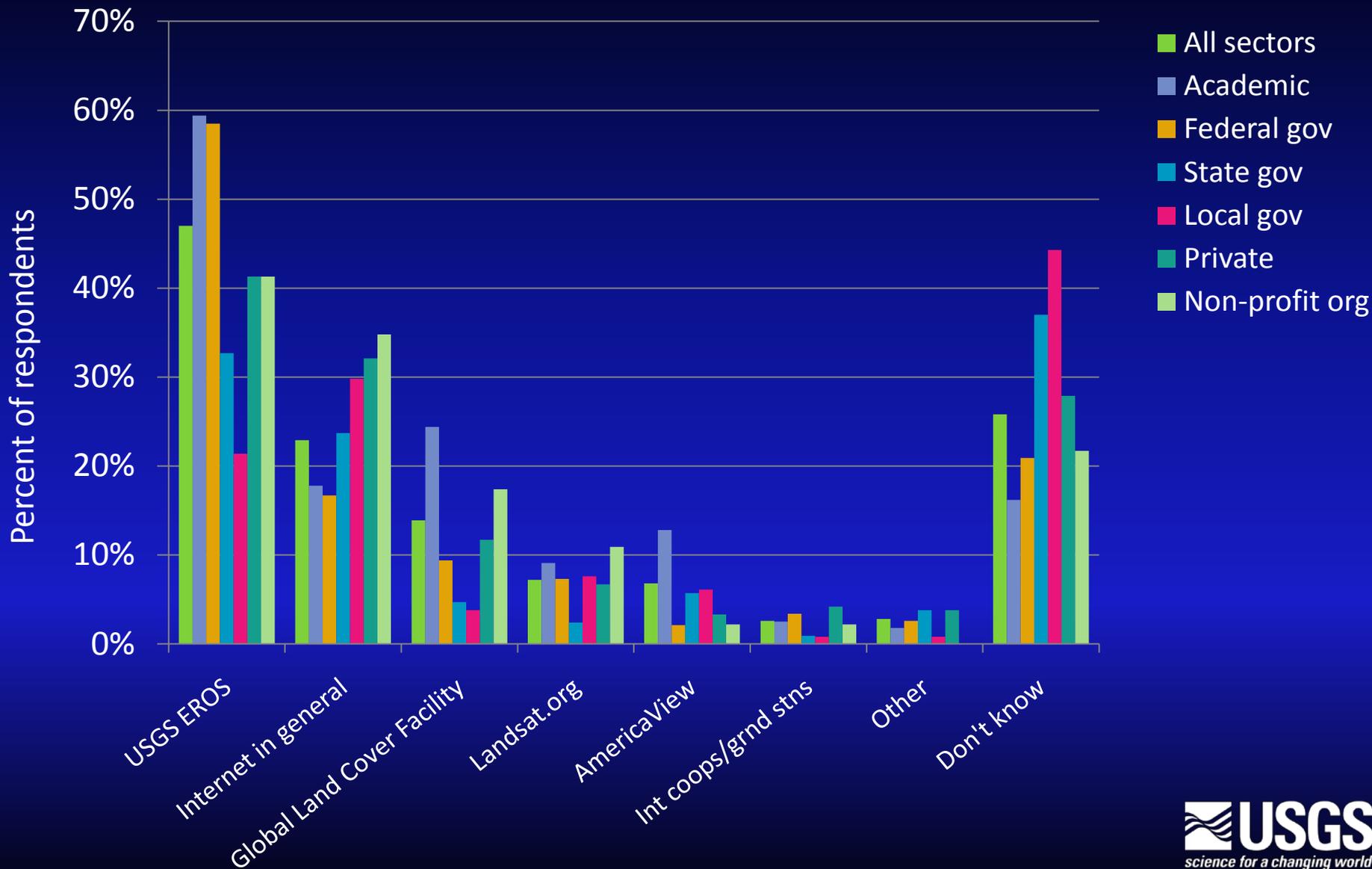
Anti-Atlas Mountains, Morocco
(<http://eros.usgs.gov/imagegallery/index.php>)

Sources of Landsat Acquisitions



*Other sources include universities, federal government agencies (besides USGS), state governments, commercial entities, and international entities. This category also includes respondents who did not obtain any imagery during that year.

2009 Sources of Landsat Acquisitions



Changes in Landsat Acquisitions

Variable	2008 Means	2009 Means	F	p	eta ²
Number of scenes acquired	91	168	290.16	<.001	.992
Percent of scenes acquired from EROS	42%	46%	25.18	<.001	.459
Dollars spent on imagery	\$5,117	\$1,040	128.37	<.001	.913
Percent dollars spent on imagery from EROS	31%	NA	NA	NA	NA

“Making the archive freely available is by far the best decision made regarding remote sensing in this country in the 10 yrs I've been working in the field.”

“States are currently extremely cost constrained. This has affected use of all types of data and the ability of states to purchase imagery. The new availability policy for LANDSAT could not have come at a better time.”

Value of Landsat Imagery

- Importance/satisfaction
- Environmental and societal benefits
- Impacts on work and costs/revenues if no longer available
- Willingness to pay for replacement imagery



The Optimist, Kalahari Desert, Namibia
(<http://eros.usgs.gov/imagegallery/index.php>)

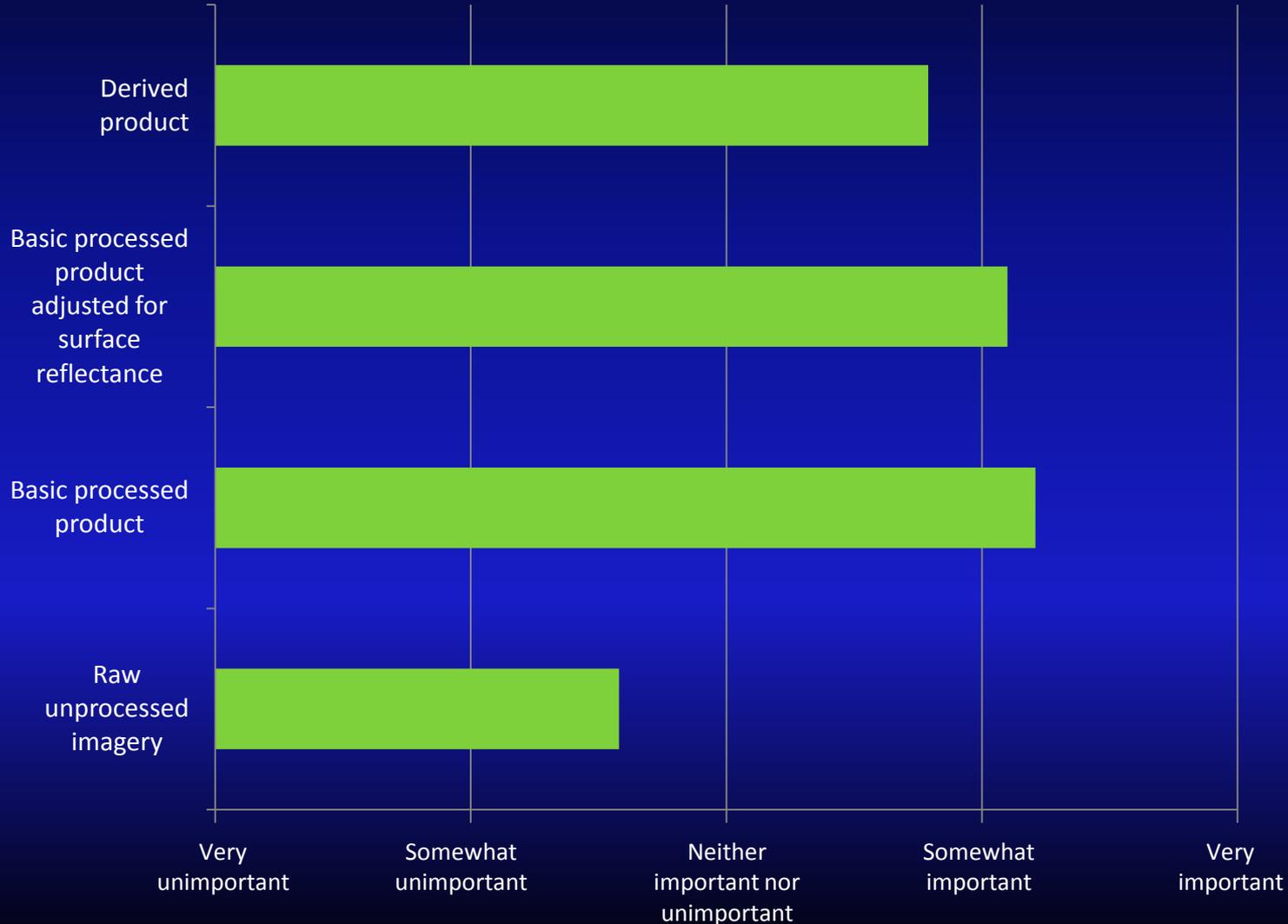
Value of Landsat Imagery: Importance/Satisfaction

- Importance of MRI products
- Importance of Landsat to work
- Importance of MRI attributes
- Satisfaction with Landsat attributes

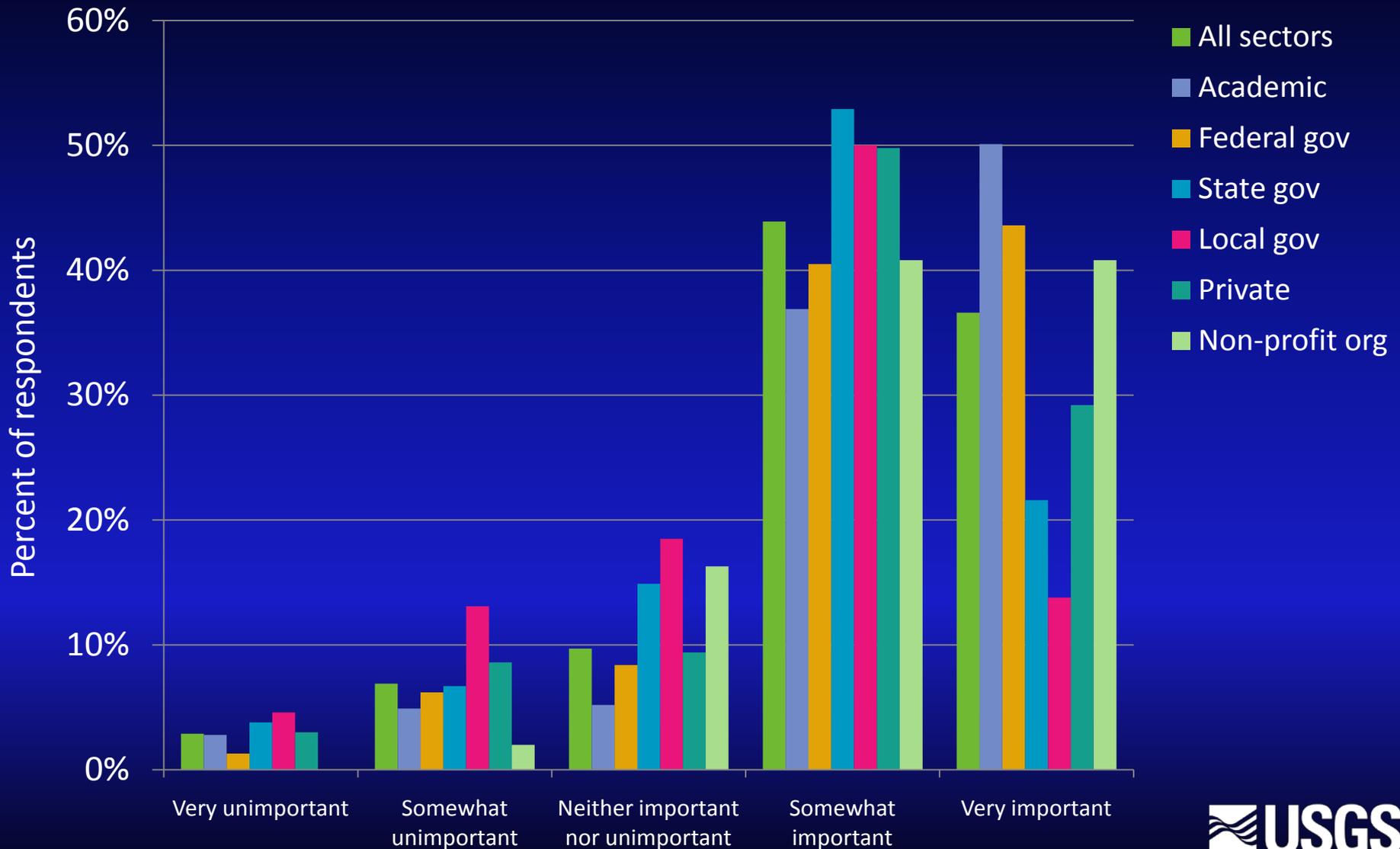


Alluvial fan, XinJiang Province, China
(<http://eros.usgs.gov/imagegallery/index.php>)

Importance of MRI Products



Overall Importance of Landsat



Landsat User Importance/Satisfaction



- ◆ Accessibility
- ▲ Area/footprint of individual scene
- ✕ Cost
- ⊕ Delivery time
- Global coverage
- Spatial resolution
- ✕ Temporal resolution/frequency of coverage

- Archive/continuity
- Availability
- Data quality assessments
- Ease of use
- ◆ Licensing/distribution restrictions
- ▲ Spectral resolution

Value of Landsat Imagery: Qualitative Responses

- Open-ended questions:
 - Landsat effect on decision-making
 - Environmental and/or societal benefits of Landsat
 - Why Landsat?
 - New and unique uses in the next 5 years

Value of Landsat Imagery: Qualitative Responses

- Effects on decision-making
 - Establishing policy (349)
 - Planning and management (222)
 - Modeling (128)
- Why Landsat?
 - Accessibility (486)
 - Cost (429)
 - Archive (228)
- Environmental and/or societal benefits
 - Assessing impacts and change over time (216)
 - Habitat/Land conservation (130)
 - Improving the environment/Reducing impacts (123)
- New and unique uses in the next 5 years
 - Time series analyses (181)
 - Integration with other programs (108)
 - Climate change monitoring/Awareness (106)

“We have been able to come up with evidence to change small town policy and challenge politics. Good science is hard to beat.”

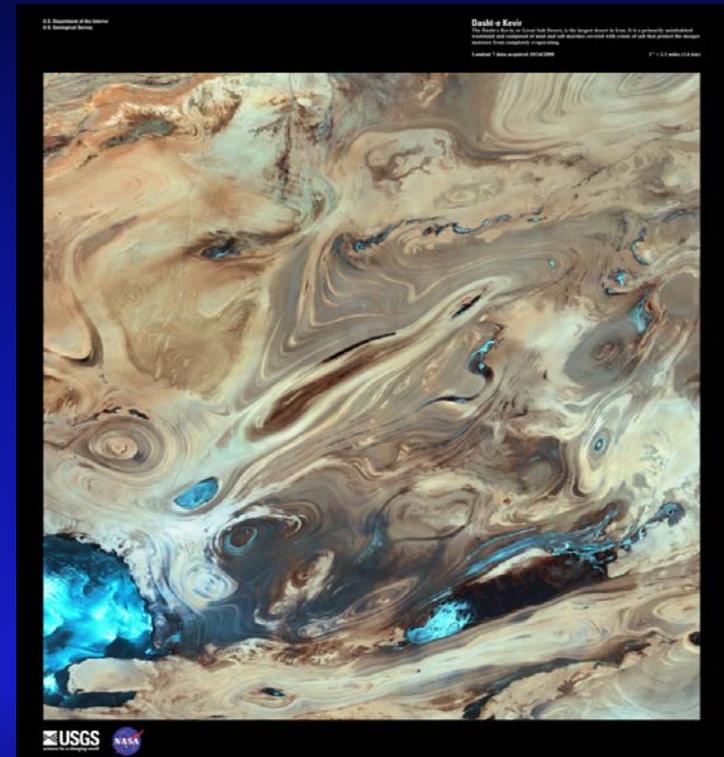
“They are free now!”

“The issuance of water rights are commonly dependent upon Landsat evaluations. These water rights provide economic value to the community at large.”

“...mostly will come from the power of comparing the long catalog with new observations, especially associated with urbanization and global warming induced changes.”

Value of Landsat Imagery: Impacts to Work If No Longer Available

- Impacts to work
 - Substitute other information or imagery
 - field work
 - other data sets (not imagery)
 - other imagery
 - Discontinue some or all of work
 - Continue work “status quo”



Dasht-e Kevir desert, Iran
(<http://eros.usgs.gov/imagegallery/index.php>)

If Landsat Was No Longer Available...

At least 1% of work would be...	Yes	No	Don't know
...substituted with other imagery or info	76%	4%	20%
...discontinued	51%	28%	21%
...continued without substituting other imagery or info	46%	30%	24%

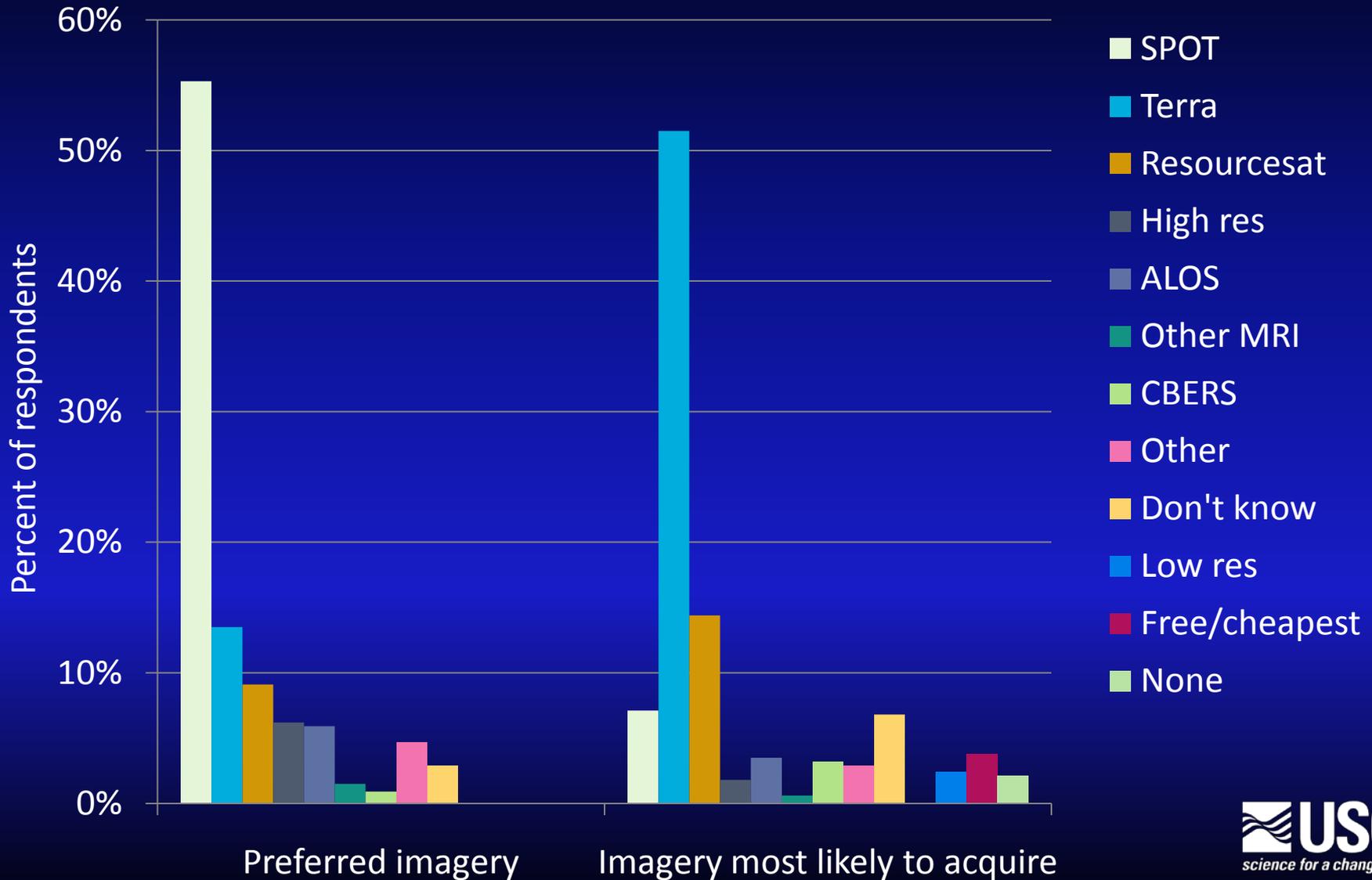
Substituting Imagery and Information

Users who would substitute (76%) would use...	Yes	No	Don't know
...other imagery	89%	1%	10%
...other data sets	69%	15%	16%
...fieldwork	63%	25%	12%

Substitute Imagery

- Preferred imagery (no budget constraints) vs. imagery most likely to acquire (within budget constraints)
 - 55% would choose same imagery regardless of budget constraints
 - Terra, SPOT, and Resourcesat
 - 40% would choose different imagery

Substitute Imagery



Value of Landsat Imagery: Impacts on Costs

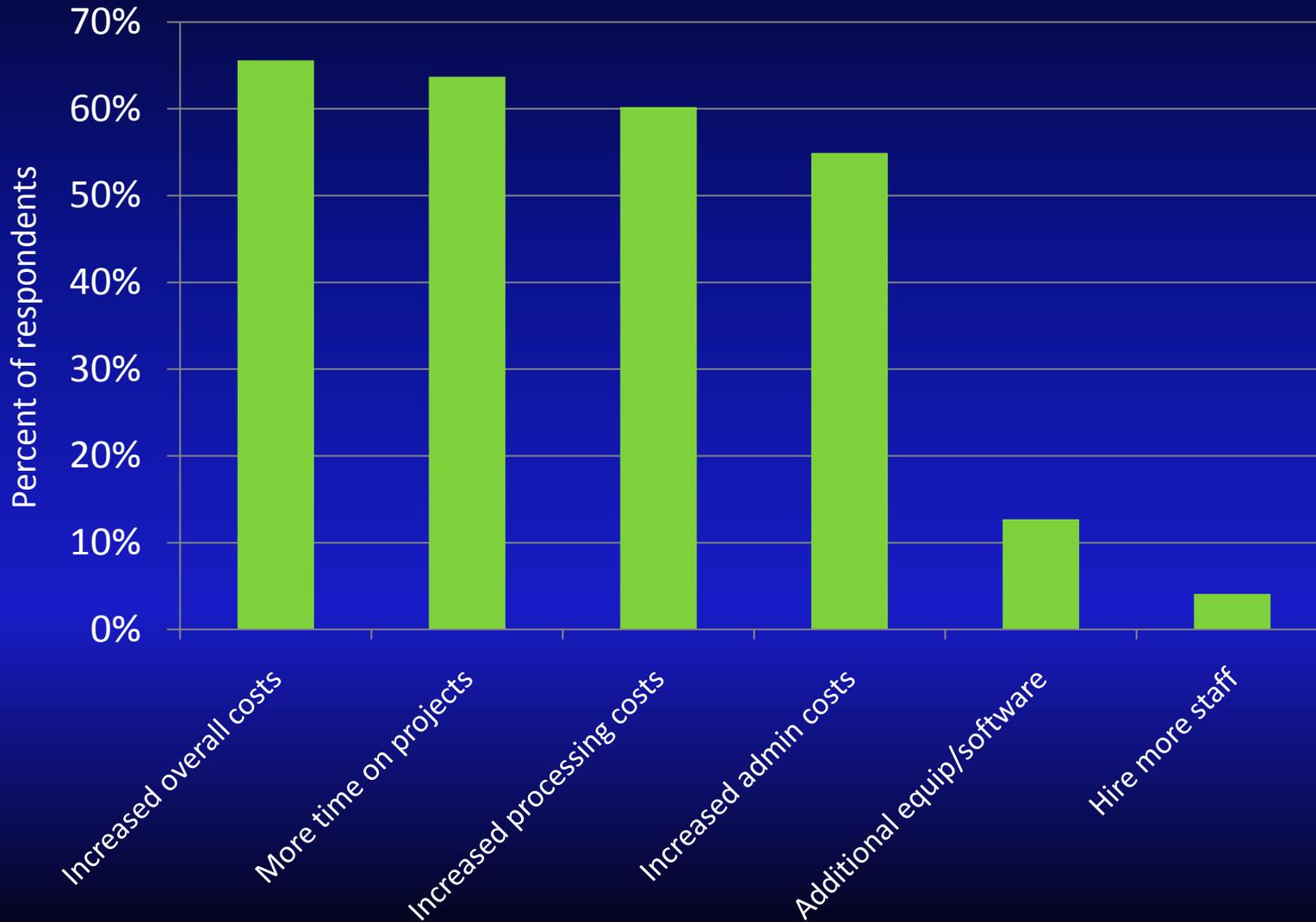
- Increases in costs
- Changes in revenue/funding



Lena River Delta, Russia

(<http://eros.usgs.gov/imagegallery/index.php>)

Value of Landsat Imagery: Impacts on Costs if No Longer Available



Impact on Costs/Revenues

- Costs
 - Half of Landsat users believed their costs would increase at least 1%
 - 41% didn't know how much their costs would increase
 - Average total percent increase in costs was 30%
- Revenues/funding
 - 20% believed revenue/funding would decrease
 - 33% believed there would be no impact
 - 43% didn't know what would happen to their revenues/funding

Value of Landsat Imagery: Willingness to Pay for Replacement

Economic benefits are measured by how much the user would pay over and above their existing costs.

Contingent Valuation Method (CVM) - uses a simulated or hypothetical market to measure what users would pay for nonmarket goods

- Realistic scenario - increase in taxes or costs
- Established method
- Thousands of applications

This net willingness to pay is the standard measure of **benefits** in benefit cost analysis.

WTP Question

“If Landsat 5 and 7 became inoperable before the next Landsat satellite is operational (scheduled to launch in 2012), you may have to obtain imagery elsewhere during the interim. Assume that you are restricted to your current project or agency budget level and that the money to pay this cost would have to come out of your existing budget. If such a break in continuity did occur and you had to pay for imagery that was equivalent to the Landsat standard product now available, would you pay \$___ for one scene covering the area equivalent to a Landsat scene?”

Choose one: YES NO

- The blank was filled in with 1 of 21 different dollar amounts that ranged from \$5 to \$5,000.

Double bounded WTP - If the cost was \$(*half/twice original*), would you pay this amount for one scene covering the area equivalent to a Landsat scene?

- \$ amounts ranged from \$2.50 to \$10,000

Asked about level of certainty of WTP

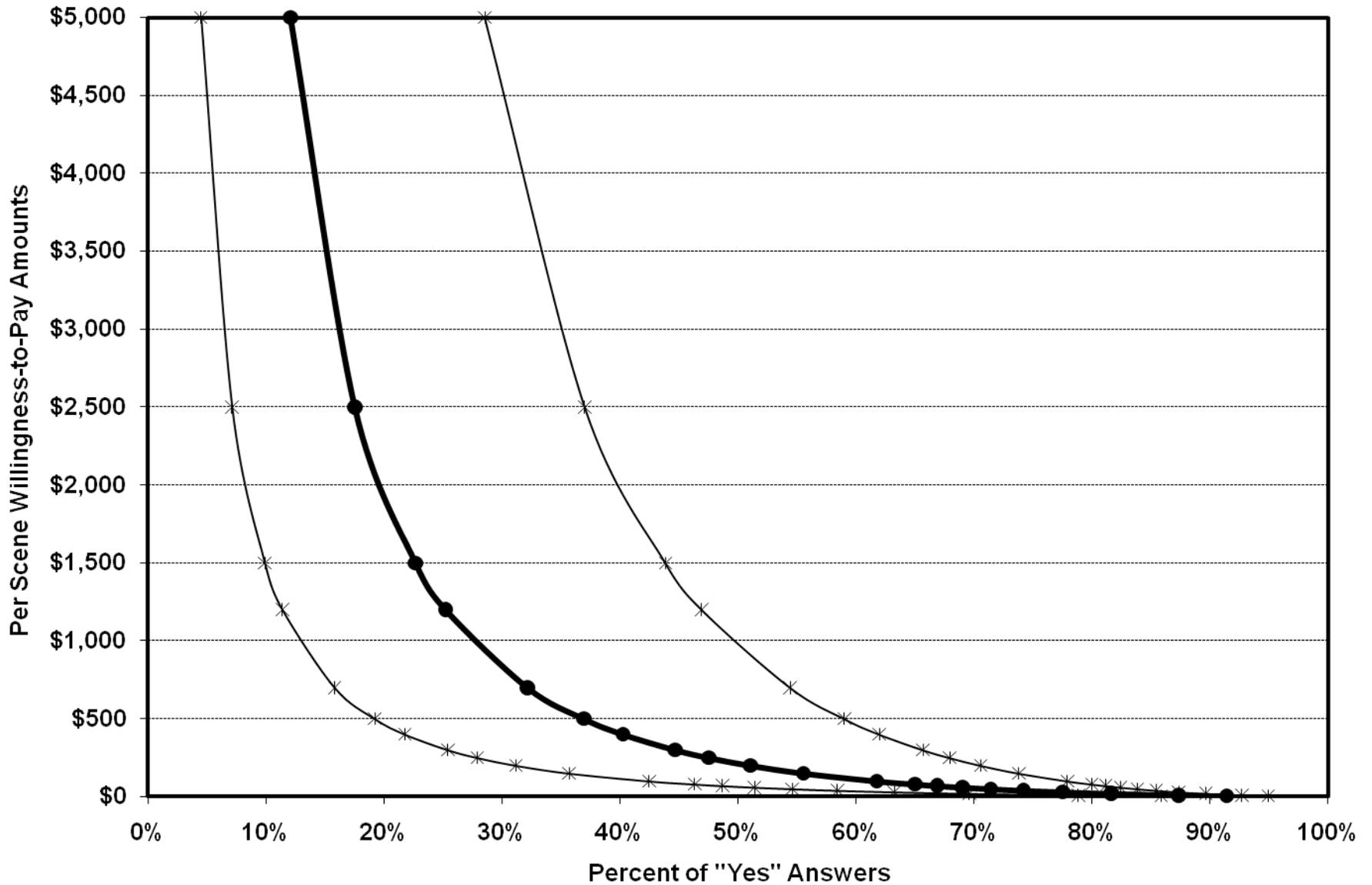
Performance of the Double Bounded Dichotomous Choice CVM

- **In concept**, the DB is intuitively appealing as statistical theory & past studies have shown that asking the 2nd follow-up WTP Question does reduce the variance of WTP estimates & gives more precision.
- But like other studies found, we too found the respondent behavioral response to the 2nd bid amount is somewhat different than the response to the first bid amount
 - For example, respondent #2329 said NO to the bid amount of \$150 and ranked their certainty as 40% and then said NO to the bid amount of \$75 and ranked their certainty as 60%

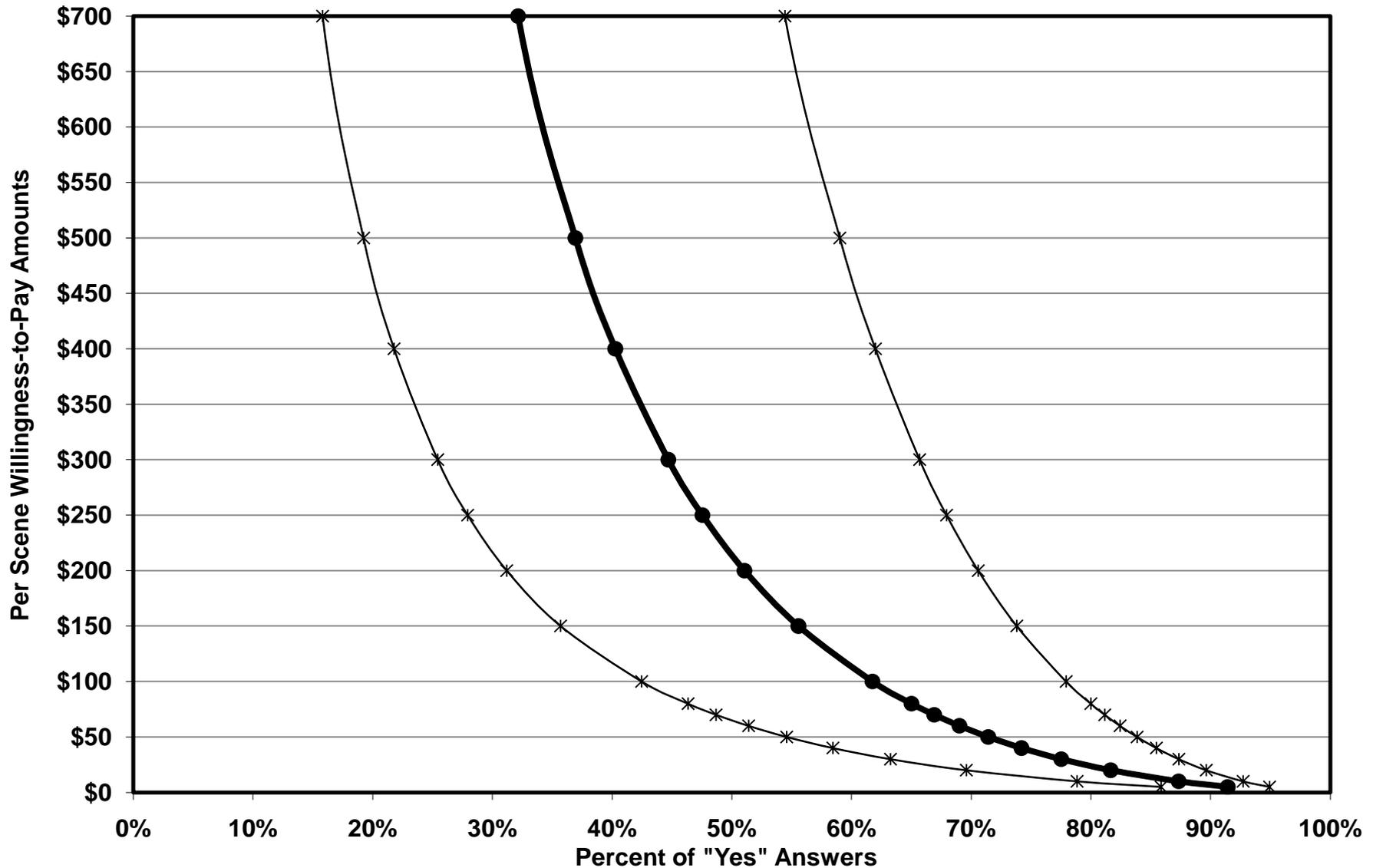
Performance of the Double Bounded Dichotomous Choice CVM

- **In practice**, respondents don't like the follow up question – they do not like that the bid amount changes.
 - The information they are giving us in answering the second question is not as good as the information in answering the first question.
 - Strategic behavior
 - Noncooperative
 - Changed preferences
- In both cases, the higher the \$ amt asked to pay, the Prob of Yes goes down, but at *somewhat* different rates in response to the first and second bid.

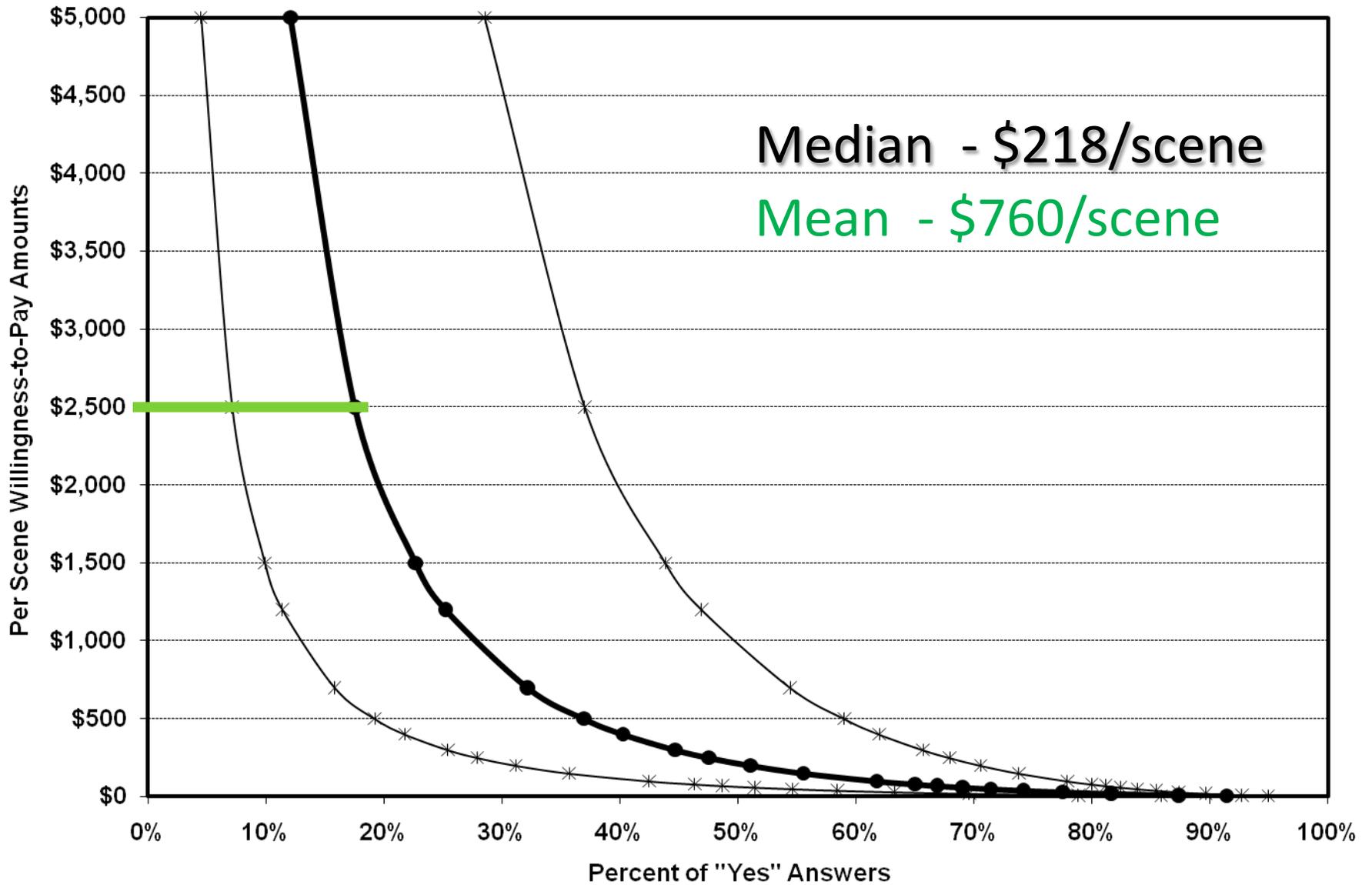
Single Bounded WTP Results



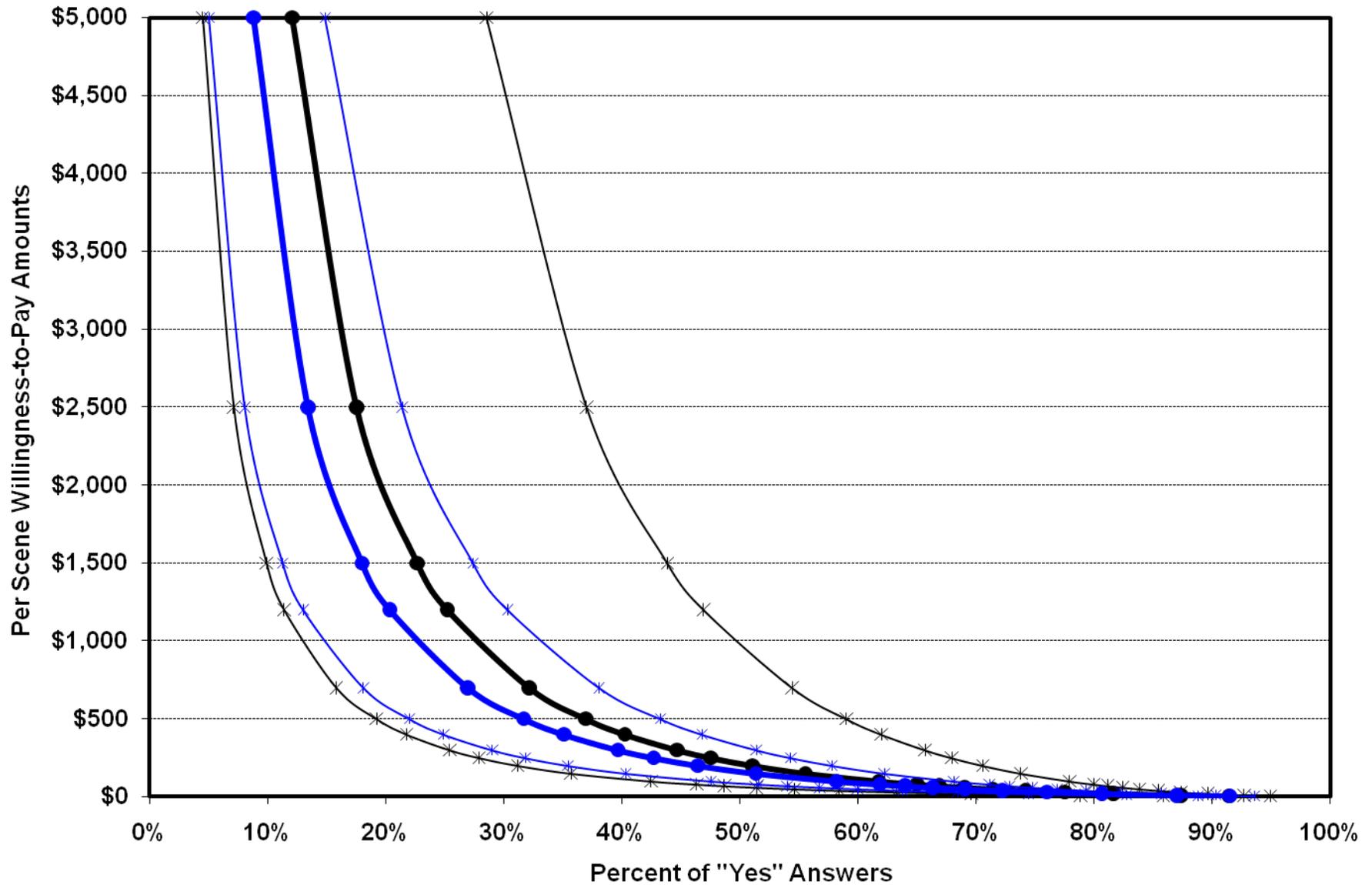
Single Bounded WTP Results



Single Bounded WTP Results



SB & DB WTP Results



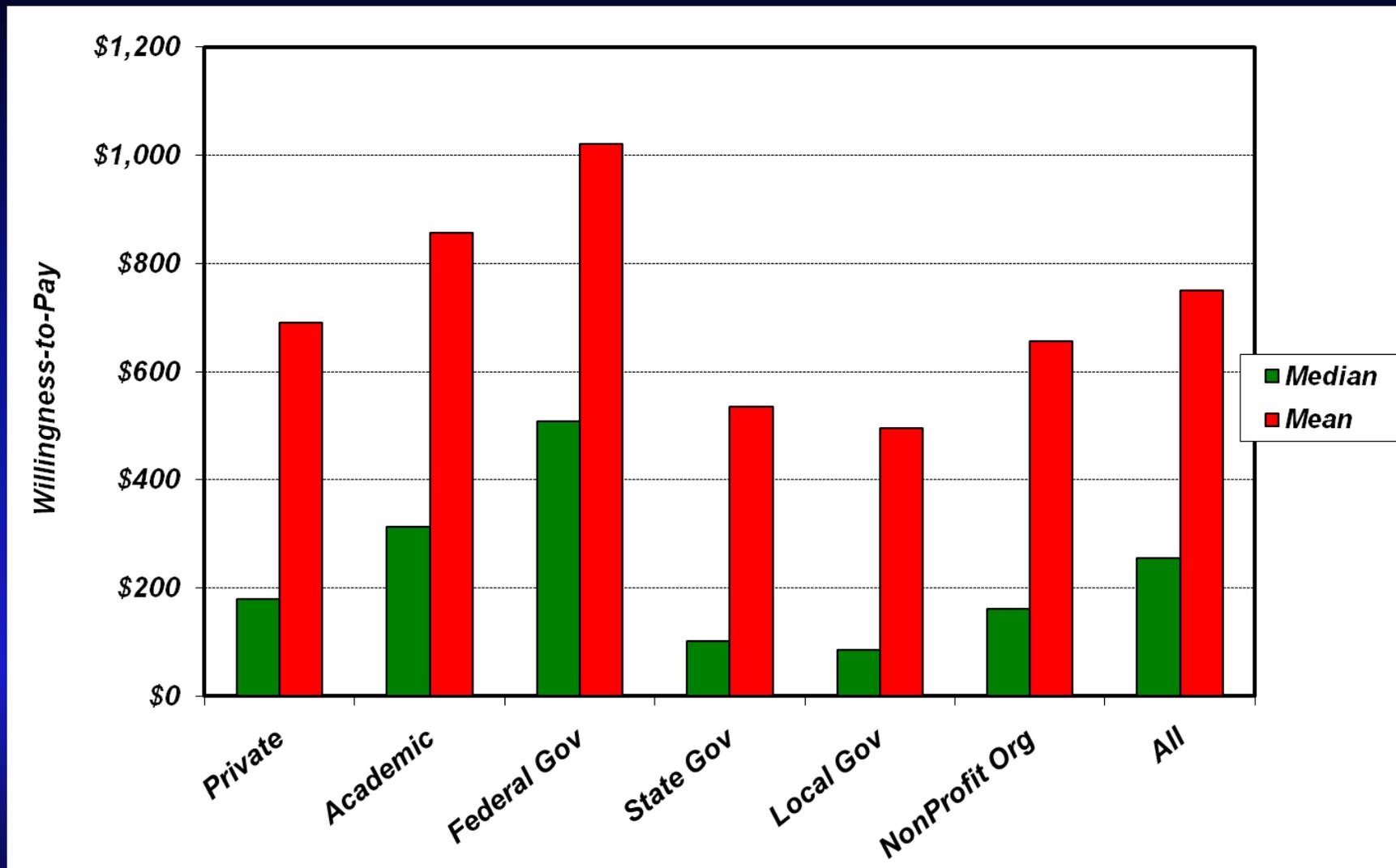
SB & DB Results

- DB improves efficiency but has problems with the second question.
 - has value but not as much as first question.
- Reasonable sector results are not present in the DB results.
 - sector variables were very insignificant. The standard errors on those variables were larger than the parameter estimates so t-statistics were less than one and the variables can reasonably be removed from the model.

Why we relied upon the Single Bounded rather than Double Bounded Dichotomous Choice CVM

- We did not expect this difference in behavior with Landsat users, as the respondents are experienced Landsat data users and know the good being valued
- We hypothesize that the difference in respondent behavior may be related to the large increases & decreases in the second \$ bid amount.
- **Given our results, at this time we believe the std binary dichotomous choice CVM results are statistically the best in terms of statistical significance of independent variables and goodness of fit (percent correct predictions is about 70%).**

Median & Mean WTP by Sector



Average across all groups - Median \$256 Mean \$751

Lessons learned for Improving the Double Bounded in Future Surveys

To attempt to obtain the added statistical precision with the DB without the “behavioral shift” between 1st & 2nd bid amount we plan to:

- Reduce the magnitude of the 2nd bid
 - step up from 2X used in the past literature to 1.25X
 - step down from one-half X to .75X
- Increase the number of initial high bid amounts since these high bid amounts are essential to accurate & precise estimates of mean WTP (which involves integration across the entire demand function).
- Try using other statistical modeling techniques such as ordered logit models which would allow for one category for each of 4 responses (YY, YN, NY, NN).

Next Steps

- This Survey (Summer/Fall)
 - Project report
 - Web visual representation
 - Journal articles
 - Remote Sensing and the Environment
 - PERS/ASPRS Highlight
- Building On (2011/2012)
 - Survey EROS customers
 - 1-2 Case Studies
 - Landfire, NLCD, Google, NGA, Foreign Ag Service, Carbon Monitoring
- Future
 - Other Case Studies
 - International users
 - Repeat of initial survey post LDCM-launch

Acknowledgments

- Tom Loveland
 - Eric Wood
 - John Dwyer
- EROS Data Center



Volga River Delta
(<http://eros.usgs.gov/imagegallery/index.php>)