



Forest Plan Monitoring

The Broader Scale Monitoring Strategy



Forest Plan Monitoring:

Where we have Been: 1982 Planning Rule

- ▶ All original Forest Plans nation-wide were developed under the 1982 Planning Rule.
- ▶ All original Plans that have completed plan revision to date have been revised under the 1982 Planning Rule.
- ▶ The Monitoring Requirements within the 1982 Planning Rule were fairly process driven and didn't focus on the interrelationships of the levels of monitoring.



Forest Plan Monitoring: 1982 Planning Rule Monitoring Requirements

- ▶ Section 219.11(d) of the 1982 Planning Rule identified monitoring as a plan component and required that monitoring and evaluation provide the basis for a periodic determination and evaluation of the effects of management.
- ▶ Section 219.12(k) of the '82 Rule required monitoring and evaluation as follows:
 - ▶ To determine how well plan objectives had been met.
 - ▶ To determine how closely plan standards and guidelines had been applied.
 - ▶ To help recommend to the Forest Supervisor changes in management direction, revisions and/or amendments to the Forest Plan as deemed necessary.
- ▶ Section 219.19(a)(6) of the '82 Rule calls for the population trends of MIS to be monitored and their relationships to habitat changes to be determined.



Forest Plan Monitoring:

1982 Planning Rule Monitoring Implementation

- ▶ Because the 1982 Planning Rule focused on what should be monitored, with little to no guidance on how plan implementation should be monitored, this resulted in Forest Plan monitoring where:
 - ▶ Forest Plan Monitoring items were often developed in isolation from other nearby Forest Plans, sometimes resulting in very dis-similar monitoring items for very similar resource conditions to be monitored.
 - ▶ The focus was often solely on the resources at the Forest-scale level, without recognition that several resources either function at a much broader scale than a single Forest, or that for several resources, monitoring would often be more efficiently conducted across multiple Forests at a scale broader than a single Forest.
 - ▶ The monitoring items developed did not necessarily lead to good adaptive management results.



Forest Plan Monitoring:

Where we are now: 2012 Planning Rule

- On May 9th, 2012, the 2012 Planning Rule went into effect, replacing the 1982 rule for all Forest Plan revisions and initiations that started after that date (all plan revisions started prior to that date could continue to revise under the provisions of the 1982 Planning Rule).
- The 2012 Planning Rule not only addresses the purposes of monitoring:
“Monitoring information should enable the responsible official to determine if a change in plan components or other plan content that guide management of resources on the plan area may be needed.” (36 CFR 219.12(a)).
- But it also addresses how we should be monitoring and who we should be coordinating with in the development of our monitoring : Regional Forester and Responsible Official, USFS State & Private Forestry and USFS Research staffs, other Federal/State/Local agencies, Tribes, partners, and other members of the public (numerous references in 36 CFR 219.12)



Forest Plan Monitoring: Monitoring Aspects: 2012 Planning Rule

- Under the 2012 Planning Rule, monitoring is composed of the following two aspects:
 1. The Plan Monitoring Program: Is the monitoring developed specific to each Forest's Plan. It "...sets out the plan monitoring questions and associated indicators...", which are "...designed to inform the management of resources on the plan area, including testing relevant assumptions, tracking relevant changes, and measuring management effectiveness and progress toward achieving or maintaining the plan's desired conditions or objectives." (36 CFR 219.12(a)(2))
 2. The broader scale monitoring strategies: are strategies developed under the responsibility of the Regional Forester for "...plan monitoring questions that can best be answered at a geographic scale broader than one plan area. (36 CFR 219.12 (b)(1))



Forest Plan Monitoring: Broader Scale Monitoring Strategies

- ▶ Under the 2012 Planning Rule, the broader scale monitoring strategies:
 - ▶ Are the responsibility of the Regional Forester (36 CFR 219.12(b))
 - ▶ Should be coordinated and integrated with each plan's Plan Monitoring Program (which is the responsibility of each Forest Supervisor), in order "...to ensure that monitoring is complementary and efficient, and that information is gathered at scales appropriate to the monitoring questions." (36 CFR 219.12(a)(3).
 - ▶ Should be undertaken "... to answer plan monitoring questions common to two or more administrative units that can best be answered at a geographic scale larger than one plan area." (FSH 1909.12, Chapter 30, Section 33)
 - ▶ Should be developed "...where it would be more efficient than monitoring limited to an individual plan area to inform the management of resources..." (FSH 1909.12, Chapter 30, Section 33.1)



Forest Plan Monitoring: Broader Scale Monitoring Strategies

- ▶ In developing the broader scale monitoring strategies the Regional Forester:
 - ▶ Shall coordinate development with the relevant responsible officials, USFS State & Private and Research staffs, other governmental entities, scientists, Tribes, partners, and the public. (36 CFR 219.12(b)(2) & FSH 1909.12, Chapter 30, Section 33.1 Item 3b)
 - ▶ Shall to the extent practicable take into account already existing USFS and external inventories, monitoring, and research programs in developing the broader scale monitoring strategies. (FSH 1909.12, Chapter 30, Section 33.12, item 3a)
 - ▶ Shall "...ensure that the broader-scale monitoring strategy is within the financial and technical capabilities of the region and complements other ongoing monitoring strategies." (36 CFR 219.12(b)(3))
- ▶ Forests can implement their Forest Plans prior to the broader scale monitoring strategy being in place – they do not have to wait for development of the strategy (36 CFR 219.12(b)(4)); the Regional Forester should develop it as soon as practicable. (36 CFR 219.12(c)(2))



Forest Plan Monitoring: Forest Status in the Southwest Region (R3)

- ▶ We have 12 Forest Plans in R3 in some form of Plan Revision/Revised Plan Implementation status:
 - ▶ 6 Plans have either been recently revised or are currently in revision under the 1982 Planning Rule:
 - ▶ This includes all National Forests in Arizona except the Tonto NF
 - ▶ Also, the Grasslands in New Mexico/Oklahoma/Texas managed by the Cibola NF
 - ▶ All revisions are recent (2012 or sooner) so their plan monitoring was developed with 2012 Rule Plan Monitoring Program concepts in mind (but no broader scale strategies)
 - ▶ All 1982 Rule based plans must transition to 2012 rule monitoring requirements, including to the broader scale monitoring strategies, once they are in place
 - ▶ 6 Plans are currently in revision under the 2012 Planning Rule:
 - ▶ This includes all National Forests in New Mexico and the Tonto NF in Arizona



Forest Plan Monitoring: So why are we here today?

- In order to develop a good broader-scale monitoring strategy:
 - A Broader-scale Monitoring Pilot effort has been initiated involving the Southwest Region (R3), Rocky Mountain Region (R2), Rocky Mountain Research Station (RMRS), and USFS Washington Office State & Private and Ecosystem Management Coordination (EMC) Staffs facilitated by the Ecological Restoration Institute (ERI) – more info on the genesis of the pilot will be provided by Rick Ullrich of EMC next.
 - As part of the pilot, ERI conducted a survey on broader scale monitoring needs for Forest Planning last fall – Amy Waltz of ERI will provide more information on the results of that survey.
 - This and other workshops (3 more are planned for Albuquerque, Denver, and Laramie later in April and in May) were developed in order to gather both partner and USFS experts to discuss potential areas to focus the Forest Planning broader scale monitoring strategies on.
- The above will lead to the development of Plan Monitoring broader-scale strategies to implement in concert with the Plan Monitoring Programs for the Forest Plans in Southwest (R3) and Rocky Mountain (R2) USFS Regions. The broader scale strategies for the two USFS Regions may differ in final content – each will fit the needs of the respective Regions.



Forest Plan Monitoring

The Broader Scale Monitoring Strategy

Genesis of the R3/R2 Pilot is next



Forest Plan Monitoring

The Broader Scale Monitoring Strategy

Genesis of the BSMS R3/R2 Pilot



Broader-Scale Monitoring Strategy

Why a Pilot?

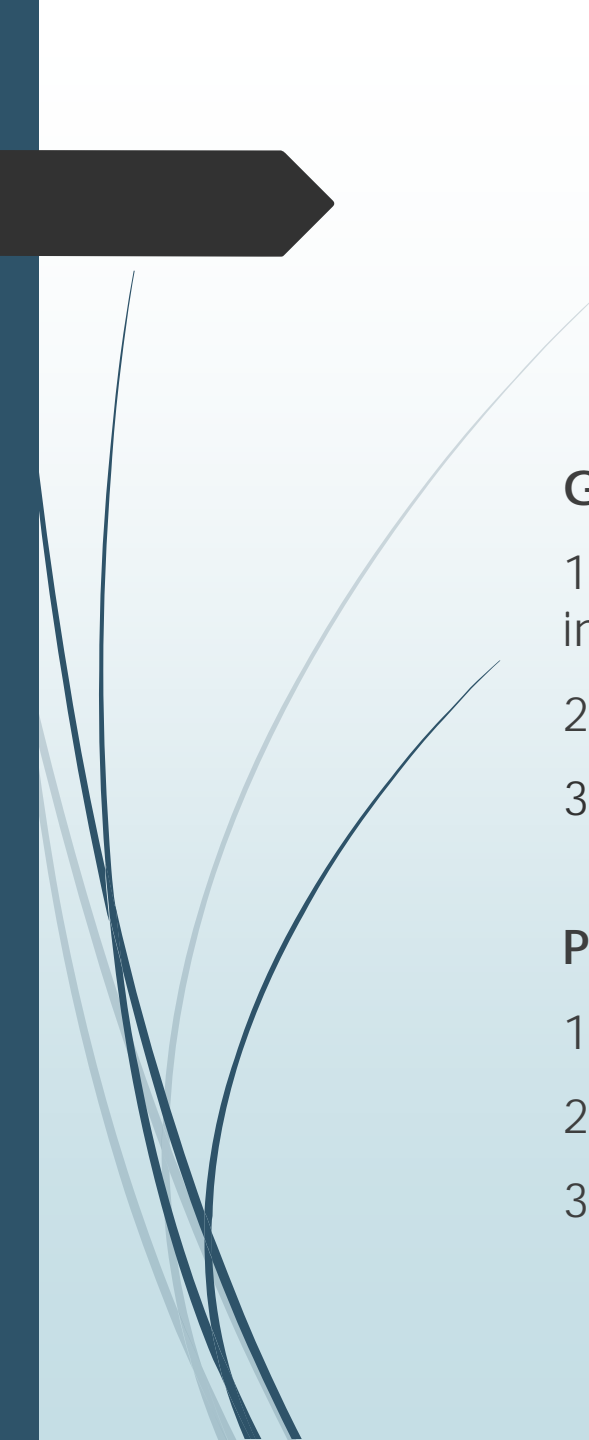
- An opportunity to collaboratively explore the concepts and implement the goals, objectives and strategic improvements contained in the Inventory, Monitoring and Assessment (IM&A) Strategy.
- Address a critical business need of the agency - implementation of the 2012 Planning Rule and Directives.
 - Redeem responsibility for Regional Foresters to develop a BSMS
 - Establish best practices for essential components of an adaptive management framework for the agency to use in collaboration with its partners.



THE IM&A Strategy

Approved: July 8, 2013

- ▶ Purpose: Identifies what the Forest Service can do within its own authorities and capabilities to improve IM&A activities and more effectively collaborate with partners in providing quality information to inform sound natural resource management decisions.
- ▶ Need - Address critical agency issues:
 - ▶ to align priority business requirements and core information needs;
 - ▶ to ensure consistency of information in time, space and quality;
 - ▶ to have a consistent transparent IM&A governance structure; and
 - ▶ to work with partners, share information and address common needs.



IM&A Strategy Content

Goals, Objectives, Strategic Improvements & Priority Implementation Actions

Goals

- 1) Support effective decision-making by providing relevant and credible information
- 2) Ensure that all IM&A activities are inclusive and comprehensive.
- 3) Ensure IM&A system is responsive and adaptive to change.

Priority Implementation Actions

- 1) Identify priority management questions and information needs
- 2) Establish IM&A governance roles & responsibilities
- 3) Develop meaningful IM&A performance metrics



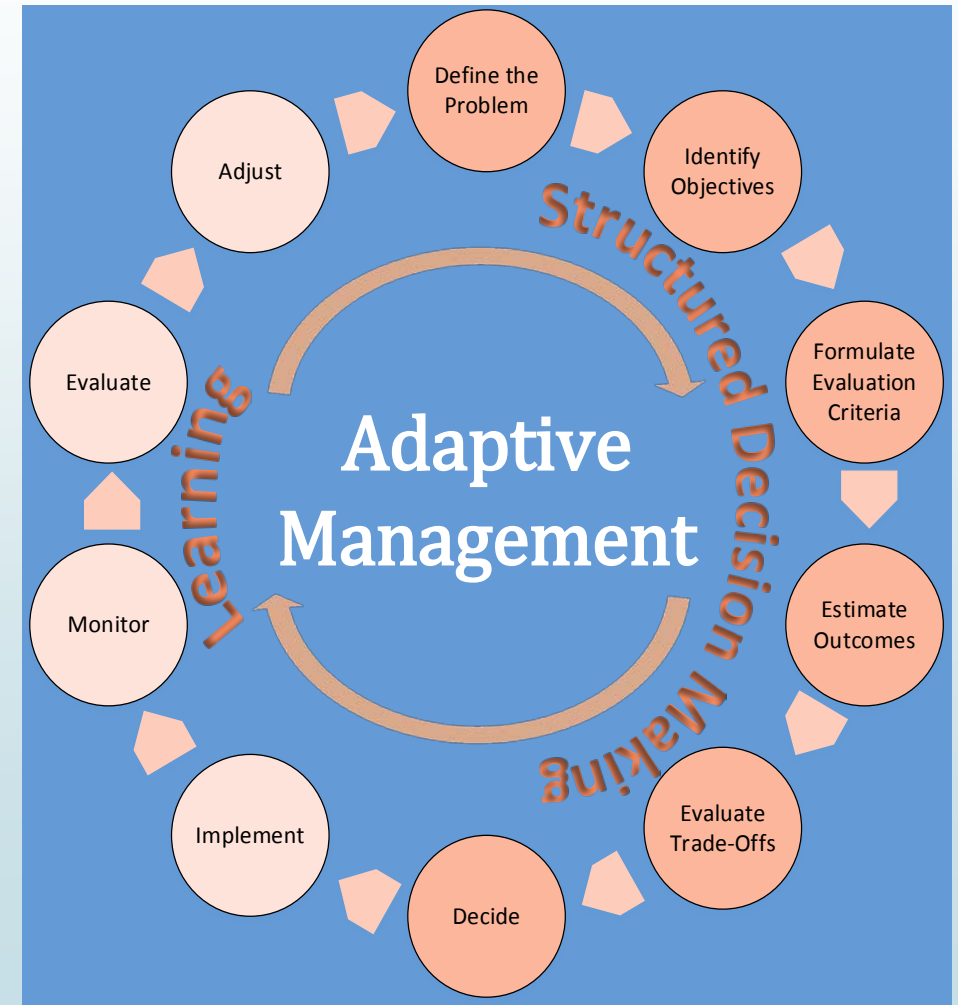
IM&A Strategy Implementation

- Multi-year Effort - need to change the way we do (IM&A) business
- Approach: Implement through leadership commitment and learning stimulated by a series of pilots, activities and communications.
- Pilots and Activities
 - Information Needs Assessment (INA) for National Management Questions
 - Region 1 Pilot: Development of regional management questions, IM&A process review, IM&A governance improvements, improving GIS capabilities and understanding Line Officer decision-making (Regions 1-4).
 - Region 3/2 Pilot: Broader-Scale Monitoring Strategy
 - Improving coordination and collaboration with States
 - Establishing an adaptive management framework for land management planning – integrating information needs for assessments, plan components and monitoring (all types, levels & scales)
 - Developing examples and communicating the opportunities to use national protocols, program assessment results and other available tools and information sources to assist in meeting land management planning and project needs.

Adaptive Management Framework(s)

Planning Rule

NE Coop Fish & Wildlife R&D





Adaptive Management Framework

- ▶ Use adaptive management approach to provide basis for adjusting management actions on a unit
- ▶ Each step in adaptive management framework has its own set of decisions
- ▶ Decision-making utilizes “evidence” from multiple dimensions
 - Scientific/technical (data, maps, documents)
 - Socio-Political (values, concerns, perspectives)
 - Organizational (governance; capacity/resources, operational)
 - Experience/Judgement of decision-maker
- ▶ Objective (and challenge): Clearly identify decisions and limit data/information needed to only support/inform each decision within the adaptive management framework

Three Steps for Monitoring Aspen Restoration



After conifer removal does aspen sprout?



Does aspen survive?

How well is aspen distributed across the landscape?





Broader-Scale Monitoring Strategy

A Vision

- ▶ Provide flexible process to implement 2012 Planning Rule intent/objectives while serving the needs of individual units;
- ▶ Promote overall efficiency and support adaptive management by monitoring conditions at a landscape or other appropriate scales across multiple units;
- ▶ Prioritize the essential portions of required monitoring items (8) using focused and efficient questions that aspire to the highest levels of scientific integrity;
- ▶ Produce high-quality data and data analysis using methods that are within the available resources and capabilities of the agency working with partners.



Broader-Scale Monitoring Benefits Everyone

► Consistency

- Increases comparability across agency units and with other landowners/users (all lands)
- Improves ability to share data, analyses, tools, etc.
- Common data used for multiple purposes - planning, programs, projects (Collect once, use often)

► Efficiency

- Reduces monitoring costs:
 - Economies of scale – coordinate similar monitoring across units and leverage partner data
 - Data acquired using a standard approach (protocol) or source (internal and external)
- Ties/limits information needed to inform decisions (adaptive management)

► Credibility

- Improves relationships and understanding with and among partners
- Inspires confidence in approach, data, analysis, results and intent



Broader-Scale Monitoring Pilot Summary

- ▶ Project Goals/Opportunities tie directly to IM&A Strategy implementation and the adaptive management framework envisioned in the Planning Rule
 - ▶ Decisions/Management Questions (Plan Components)
 - ▶ Monitoring Questions and Indicators
 - ▶ Best addressed at the Local Unit Level
 - ▶ Best addressed at a Broader Scale/Level
 - ▶ Explore roles of stakeholders/partners – multi-partner monitoring
 - ▶ Identify existing sources of data, tools and protocols

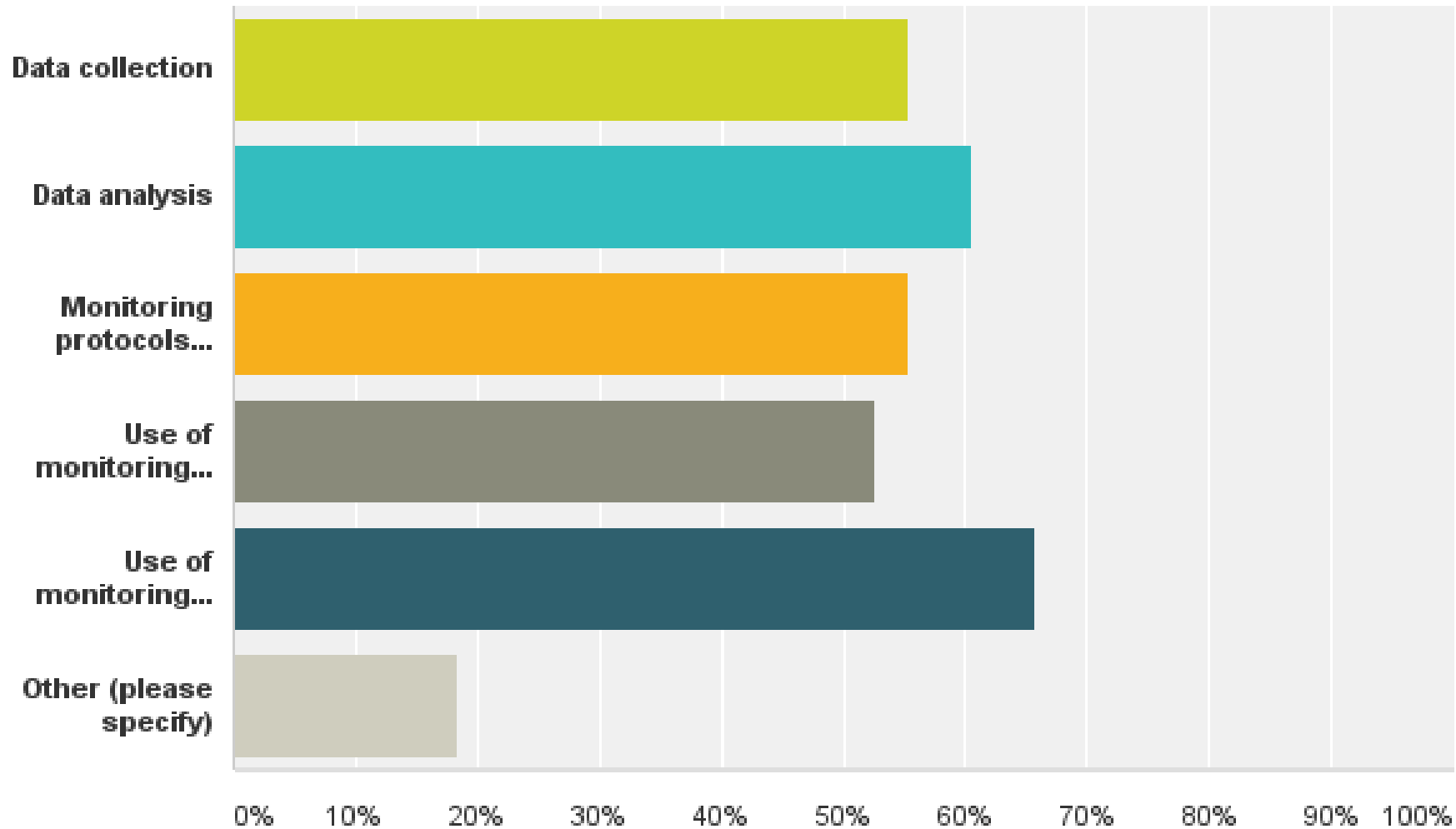


Questions ???

Broader-Scale Monitoring
Pre Workshop Survey
Arizona

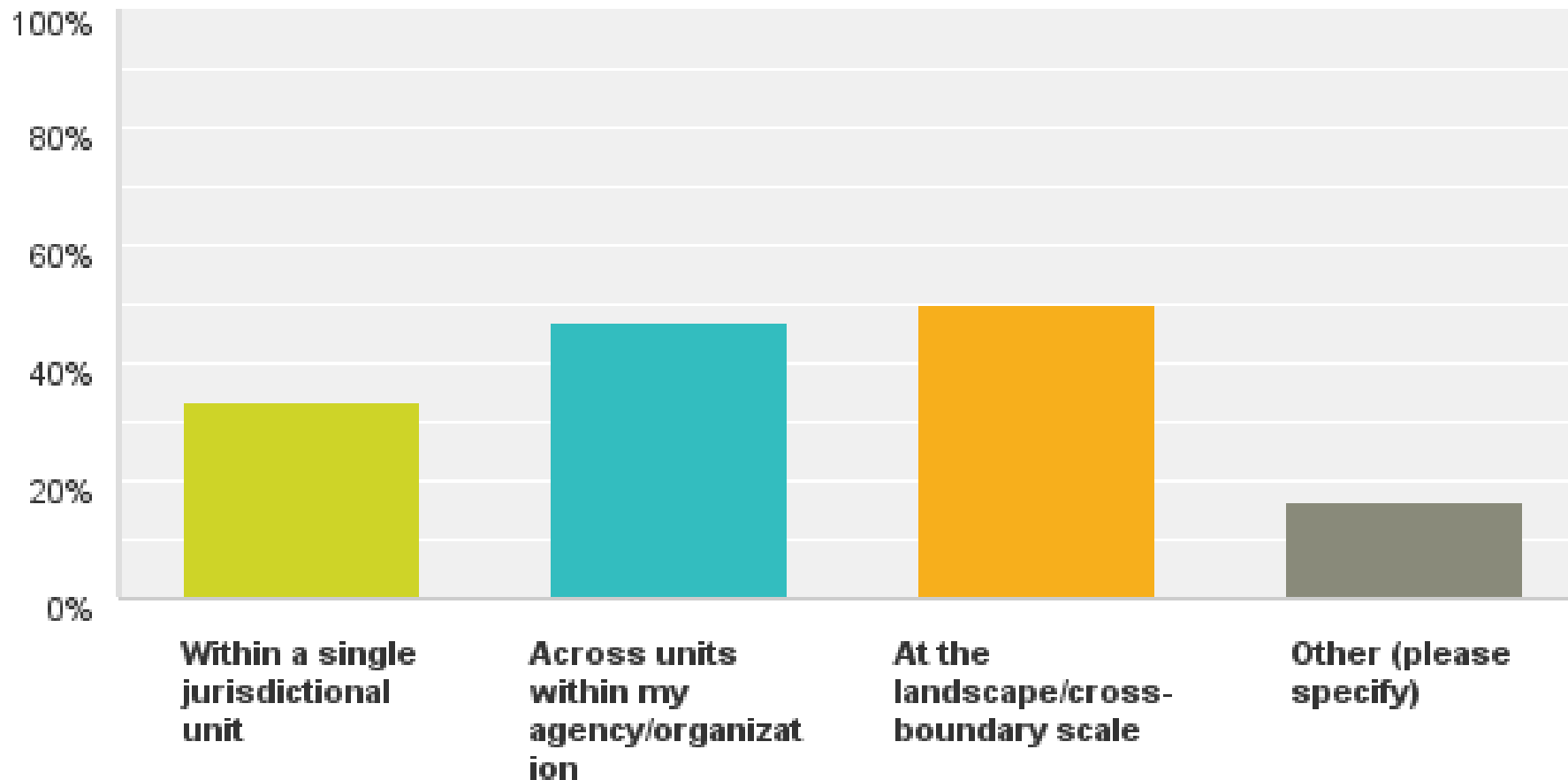
Q3 In what capacity are you involved with monitoring? (Check all that apply)

Answered: 38 Skipped: 1



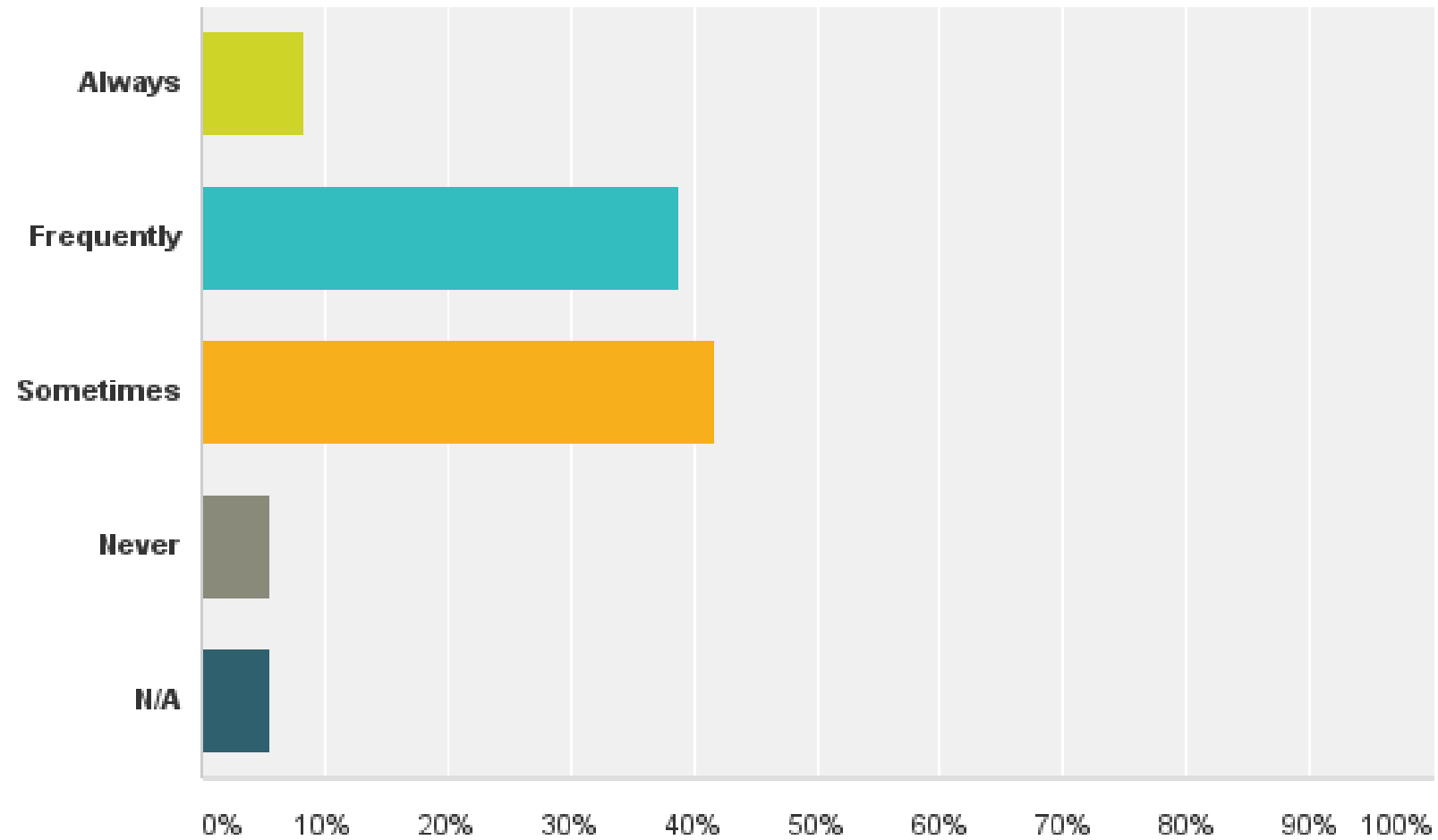
Q4 At what scales do you currently do your monitoring? (If you do more than one type of monitoring, check all that apply)

Answered: 36 Skipped: 3



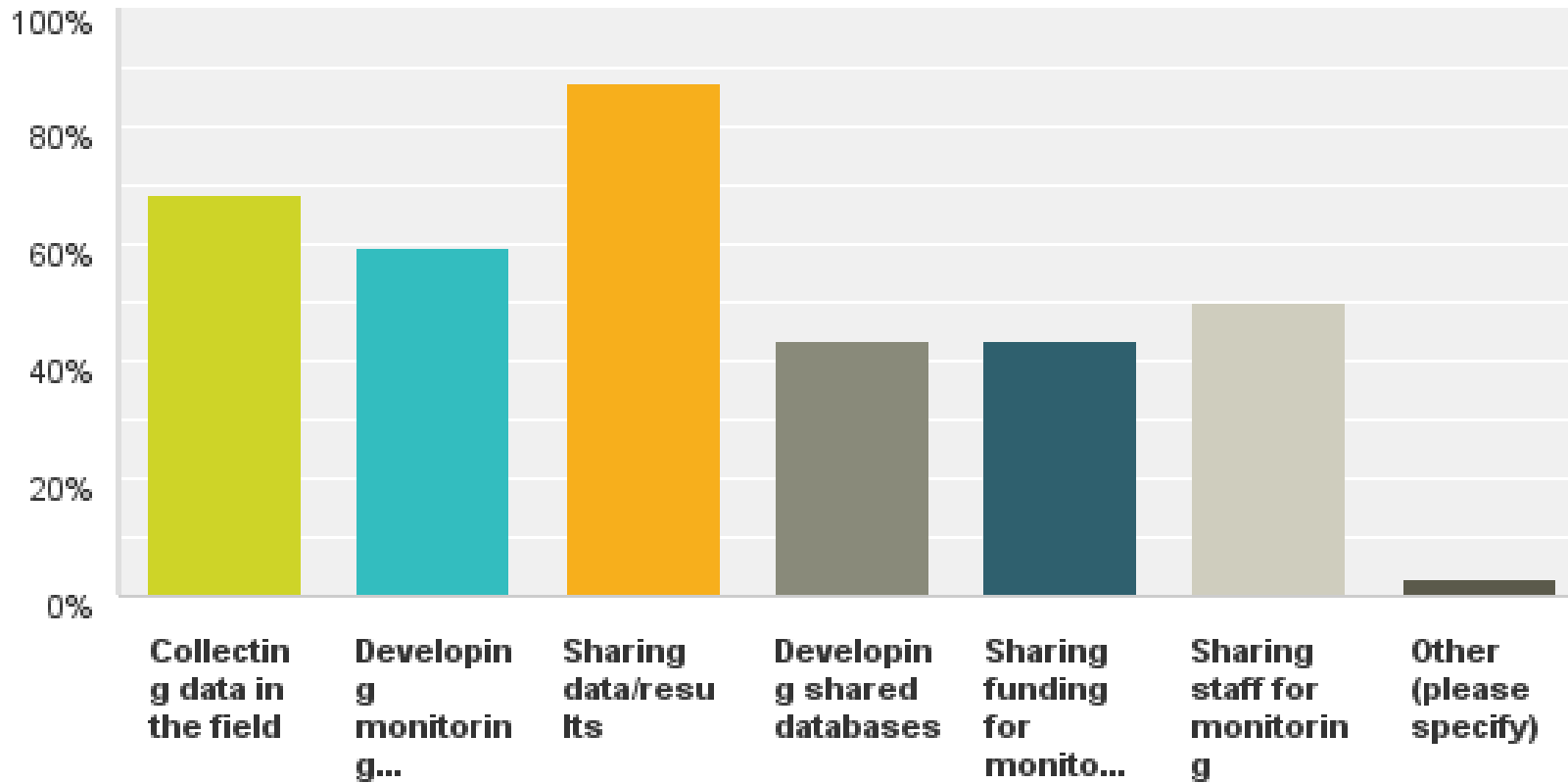
Q6 How often do you work with other organizations/agencies on monitoring?

Answered: 36 Skipped: 3



Q7 What aspects of monitoring do you work with partners on? (Check all that apply)

Answered: 32 Skipped: 7



Other: Education and Outreach

What aspects of monitoring do you work with partners on?

Sharing data/results	28
Collecting data in the field	22
Developing monitoring protocols	19
Sharing staff for monitoring	16
Developing shared databases	14
Sharing funding for monitoring	14
Other: education and outreach	

If you do, which organizations/agencies do you partner with on monitoring?

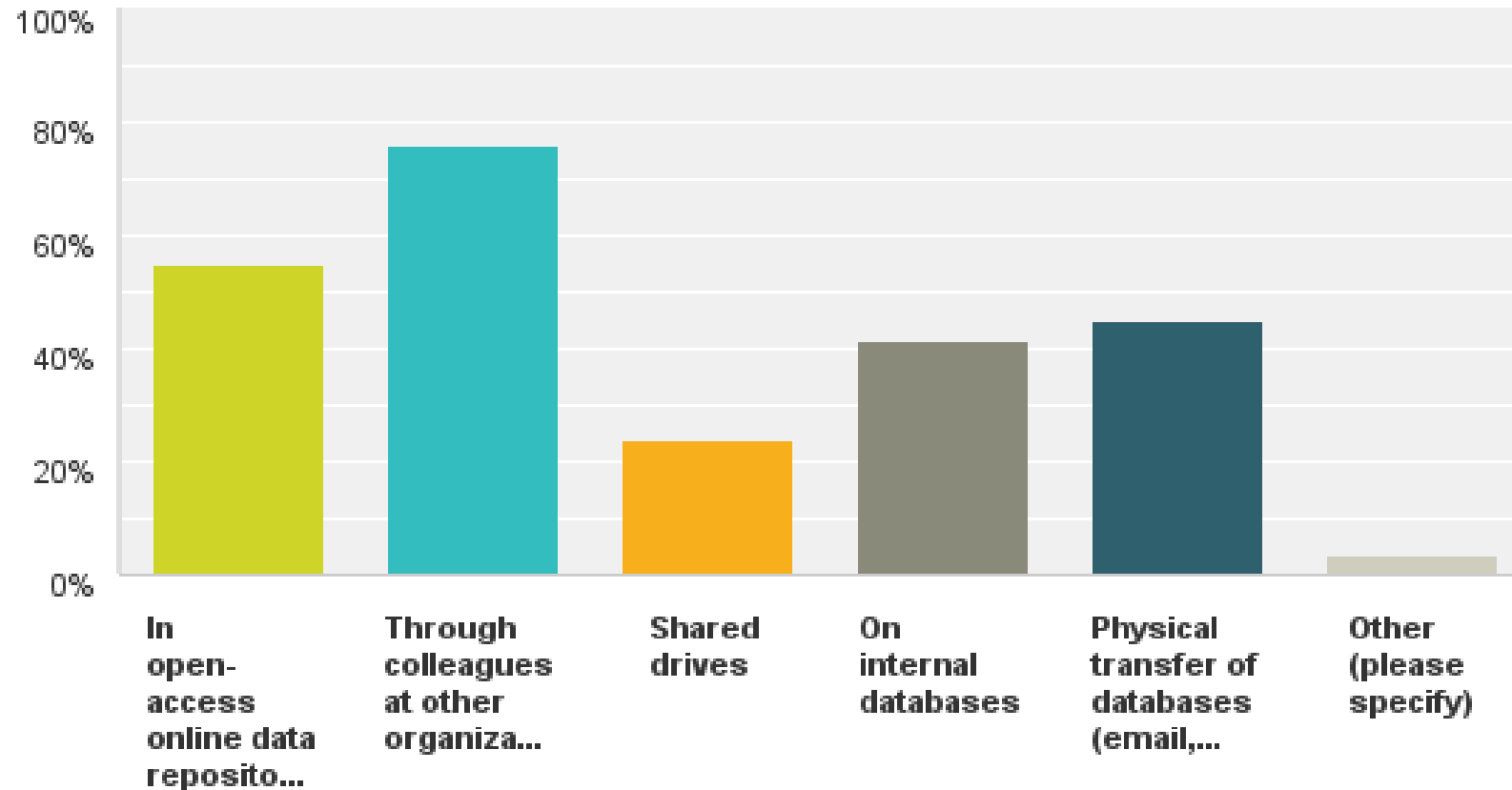
<p>4FRI Stakeholder Group</p> <p>Multi-party Monitoring Board</p> <p>Arizona Department of Transportation</p> <p>Arizona Game and Fish Dept (10)</p> <p>Audubon</p> <p>Bat Conservation International</p> <p>Bird Conservancies</p> <p>Bird Conservancy of the Rockies (3)</p> <p>BLM (10)</p> <p>Colorado demography office (data)</p> <p>Desert LCC and DLCC partners (3)</p> <p>Department of Defense</p>	<p>FIA</p> <p>Friends of the Verde River Greenway</p> <p>Grand Canyon Trust</p> <p>Headwaters economics - data</p> <p>Joint Venture (SJV)</p> <p>Natural Heritage New Mexico (2)</p> <p>New Mexico Game and Fish</p> <p>New Mexico State University</p> <p>Northern Arizona University (3)</p> <p>NPS (5)</p> <p>NRCS (3)</p> <p>NRI</p> <p>Pima County</p>	<p>Ranching partners</p> <p>Rocky Mountain Research Laboratory</p> <p>SEInet</p> <p>Southwest Fire Science Consortium</p> <p>Spring Stewardship Institute (4)</p> <p>Texas A&M</p> <p>The Nature Conservancy (3)</p> <p>Universities (Univ of AZ, Univ of WY, others)</p> <p>US Fish and Wildlife Service (2)</p> <p>USFS (11)</p> <p>USFWS (4)</p> <p>USGS (2)</p>
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Data Related Questions

Tomorrow

Q9 If you access shared data, how do you access it? (Check all that apply)

Answered: 29 Skipped: 9



Other: Restricted online data repositories

Are there existing datasets that you would like to use, but cannot access or don't know how to?

- Rangeland health/Condition
- TEUI
- NRIS or other USFS data
- BLM datasets
- NPS datasets
- Our goal is to establish an Avian Knowledge Network for the Southwest
- Roads and fences layers that match between USFS and BLM and are up to date (spatial)
- Public lands livestock grazing information (AUMs, forage utilization; spatial)
- Landscape-level or site-level drought risk, particularly for water resource availability (spatial)
- Existing vegetation type change over time (spatial)
- Water resource condition (e.g., springs condition - developed or not developed)
- soil moisture data, NDVI, LCC datasets; FORWarn
- FIA
- Broad-scale bird datasets (e.g., IMBCR)

What are the challenges related to the datasets you currently use?

The data is not up to date	14
The system for inputting data is difficult	12
The data is hard to access	10
The data is not in a format I can easily use	10
The data is hard for people I work with to access	9
The data system is disorganized or difficult to understand	3

Other:

- Inconsistent
- Monitoring is a collateral duty for many resources specialists in the FS, and databases are constantly changing. Without a focus on monitoring, it is hard to stay up to date on data entry, retrieval and analyses.
- Not always available across jurisdictional boundaries
- Lack of funding → reduced data collection → difficult to maintain trend data
- Obtaining proprietary information from NGOs
- Spatial and/or temporal resolution not sufficient for my analyses
- Knowing who to get it from and follow up once it is promised
- Different formats/protocols make it difficult to crosswalk

Broad Scale Monitoring Workshop
Activities on National Forest Systems Lands:
Arizona

April 5, 2016

Broad scale Monitoring

- Assessments where key elements have been re-evaluated to determine a change or demonstrate a trend.
- Inventory where repeat measurements yield changed conditions and trends.
- Datasets that are designed and tooled for the broad scale (not fine or mid-scale data).

National Hierarchical Framework of Ecological Units

Subregional Scale:

Subregions are characterized by combinations of climate, geomorphic process, topography, and stratigraphy that influence moisture availability and exposure to radiant solar energy, which in turn directly control hydrologic function, soil-forming processes, and potential natural community distributions. Sections and Subsections are the two ecological units mapped at this scale.

Table 1. National hierarchy of ecological units

<i>Planning and analysis scale</i>	<i>Ecological Units</i>	<i>Purpose, objectives, and general use</i>
Ecoregion Global Continenta Regional	Domain Division Province	Broad applicability for modeling and sampling. Strategic planning and assessment. International planning.
Subregion	Section Subsection	Strategic, multiforest, statewide, and multiagency analysis and assessment.
Landscape	Landtype association	Forest or areawide planning, and watershed analysis.
Land unit	Landtype Landtype phase	Project and management area planning and analysis.
Hierarchy can be expanded by user to smaller geographical areas and more detailed ecological units if needed.		Very detailed project planning.

Forest Inventory and Analysis (FIA)

Forest Inventory and Analysis: FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership.

Arizona: 1985-1999 periodic sampling

2008-2014+ annualized sampling

INTERIOR WEST FOREST INVENTORY & ANALYSIS P2 FIELD PROCEDURES



January, 2016
(V7.00)



Forest Insects and Disease Surveys

Aerial detections surveys: Aerial surveying monitors forest health conditions more efficiently and economically than other methods. During the surveys, forestry staff look for areas with dying trees (from bark beetles, drought, other factors), various types of defoliation, and abiotic impacts such as from storms and weather patterns.

<http://www.fs.usda.gov/detail/r3/forest-grasslandhealth/insects-diseases/?cid=STELPRDB5228474>

Forest Insect and Disease Conditions in the Southwestern Region, 2014



Wildlife

Site Occupancy by Mexican Spotted Owls (*Strix occidentalis lucida*) in the US Forest Service Southwestern Region, 2015

Monitoring of Mexican Spotted Owl:

Listed as threatened under ESA 1993.
Revised MSO recovery plan 2012. Contracted
with Bird Conservancy of the Rockies 2013.
Two hundred and one sites surveyed at least
twice in 2015. The sites were a random
subset of 2014 survey.

kdmalcolm@fs.fed.us



16 November 2015

Watershed

Watershed Condition Classification: Initial classification completed in 2010. Reassessment completed in 2015.

Apache-Sitgreaves NF: 3

Coconino NF: 2

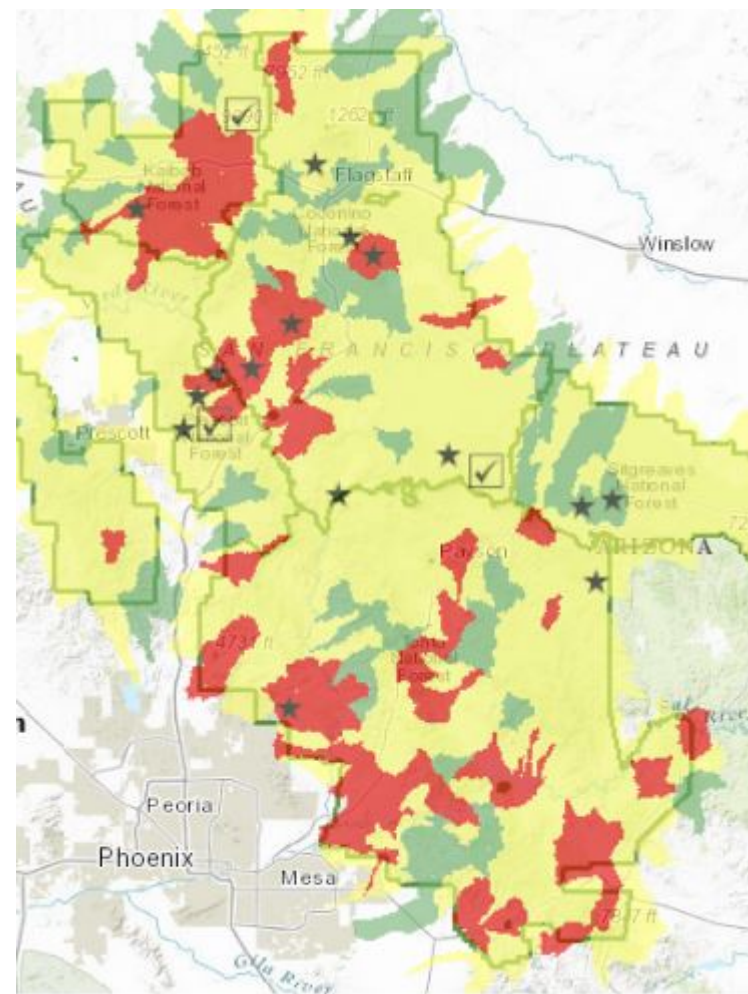
Coronado NF: 0 (2017)

Kaibab NF: 116

Prescott NF: 16

Tonto NF: 42

http://www.fs.fed.us/biology/watershed/condition_framework.html



Stream Temperature

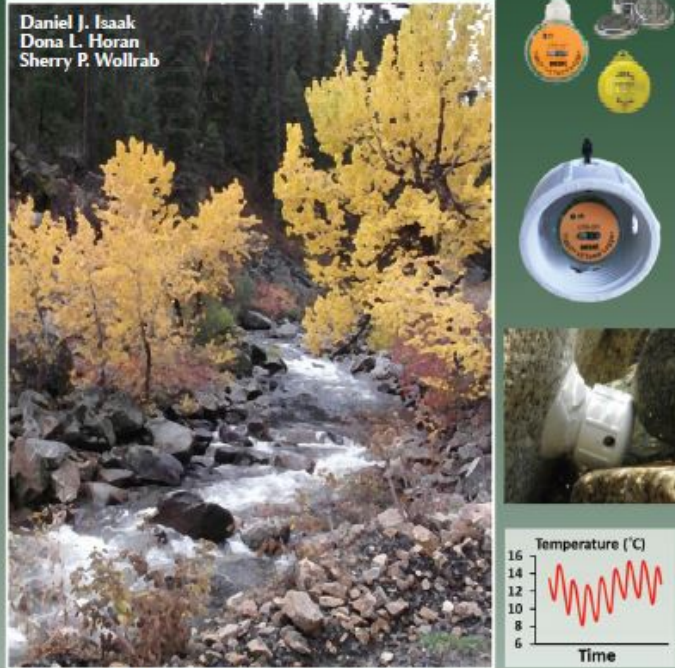
Multi-Forest Stream Temperature Monitoring:

Thermal regimes are important to aquatic ecosystems because they strongly dictate species distributions, productivity, and abundance. Inexpensive digital temperature loggers, geographic information systems (GIS), remote sensing technologies, and new spatial analyses are facilitating the development of temperature models and monitoring networks applicable at broad spatial scales.

http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml

A Simple Protocol Using Underwater Epoxy to Install Annual Temperature Monitoring Sites in Rivers and Streams

Daniel J. Isaak
Dona L. Horan
Sherry P. Wollrab



The composite image illustrates the protocol. On the left, a photograph shows a rocky stream flowing through a forest with vibrant yellow autumn trees. On the right, there are three smaller images: the top one shows a white epoxy container and a yellow temperature logger; the middle one shows a white epoxy container with a temperature logger inside; the bottom one shows a white epoxy container installed in a stream bed. Below these images is a line graph showing temperature fluctuations over time.

Temperature (°C)

Time

United States Department of Agriculture / Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-314
October 2013

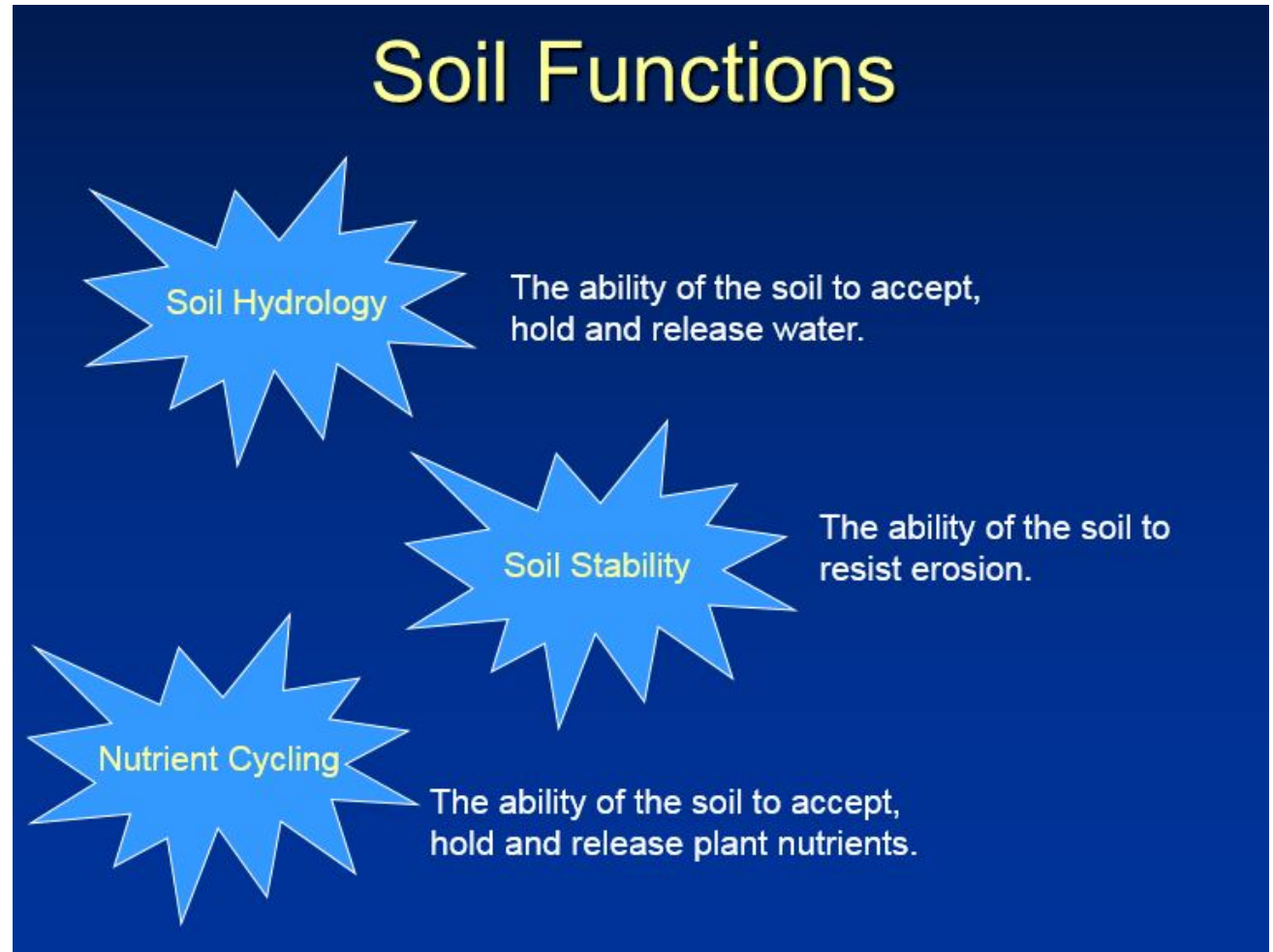
Soil Quality

Soil Quality/Soil Condition: An evaluation of soil quality based on an interpretation of factors which affect vital soil functions.

1991 GTES; Carleton, Owen et., al.

2010 Watershed Condition Classification;

20008-2016; Forest plan revision



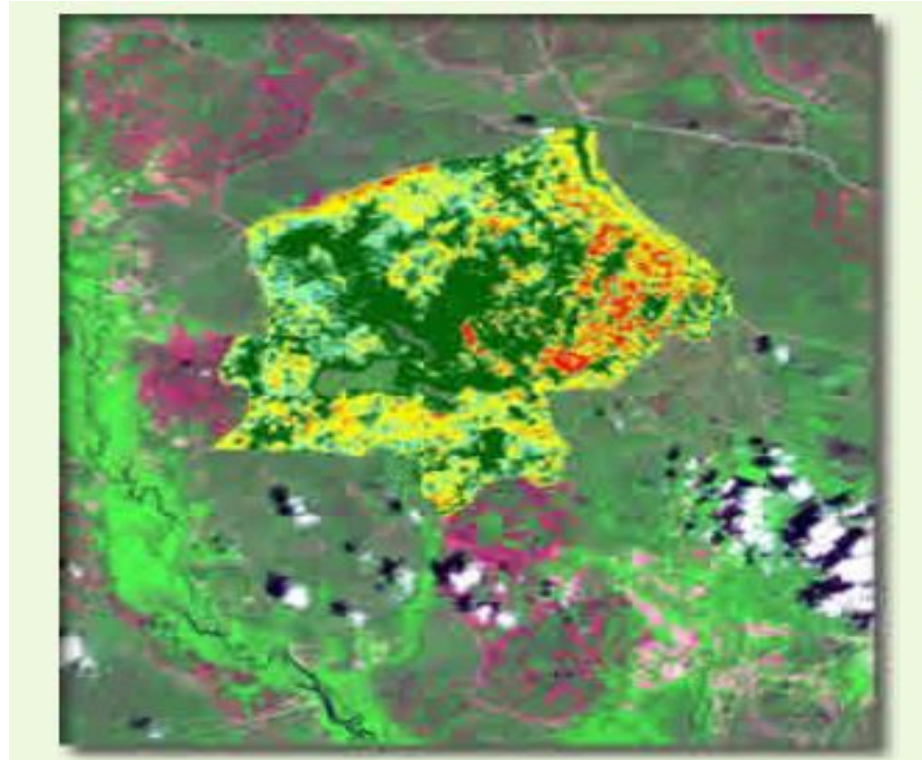
Fire Management & Science

MTBS-Monitoring Trends in burn severity:

The primary objective of MTBS is to provide consistent summary information to WFLC on the location, extent and magnitude of burn severity on all lands in the US, including Alaska and Hawaii for the period of 1984 and beyond.

In general, more acres are being burned in the West and the proportion of high burn severity has increased.

<http://mtbs.gov/>



Climate and Climate Change

Monitoring trends in climate change: Four strategic areas;

1. *Detection and Evaluation* – A unified monitoring system would provide a mechanism to detect and evaluate national and regional trends in climate change impacts on forest and grassland health and productivity.

2. *Information Delivery* – A unified monitoring system would provide reliable, timely, and transparent information to inform planning, decision making and implementation at all levels by Forest Service line officers, our partners, and communities.

3. *Partnerships* – Partnerships must be a priority in addressing climate change and conservation across areas that are shared among public, private and community interests.

4. *Science Integration* - A unified monitoring system supports adaptive management by facilitating the integration of science and management. Coordinated and enhanced monitoring systems provide a mechanism for translating relevant science into land management applications, using predictive models and decision support tools.

Unified Multi-Scale Monitoring Approach Summary Report



Monitoring Team for Climate Change
July 2009





A Brief Summary of Arizona Game and Fish Department Monitoring Activities

Esther Rubin, Arizona Game and Fish Department

Some generalities:

- Monitoring is focused on wildlife
- Monitoring priorities are often driven by commitments to threatened and endangered species conservation or by funding considerations

What do we monitor?

- Mammals
 - Game species
 - Predators
 - Common species
 - T&E species
 - Non-native, invasive species
- Birds
 - Game species
 - T&E species
 - Common species



What do we monitor? (continued)

- Fish
 - Sportfish
 - Native fish
 - Non-native, invasive species
- Reptiles and Amphibians
 - T&E Species
 - Common species



What do we monitor? (continued)

- Invertebrates
- Plants
 - T&E Species
 - Common species
- Diseases
- Genetics



Who does our monitoring?

- Our biologists
 - Game, nongame, and fisheries specialists
 - Regional Wildlife Managers
 - Research and Contract branches biologists
- Outside researchers and biologists
 - Universities, NGOs
- The public



How is monitoring data collected?

- Structured surveys
 - Aerial, electrofish, and foot surveys, etc.
- Online reporting tools
 - iNaturalist
 - iMAPInvasives, etc.
- Scientific collection permit process
- Collaborative agreements





Southwest Climate
Science Center

Toward Actionable Science:

AN OVERVIEW OF THE DOI SOUTHWEST CLIMATE SCIENCE CENTER (SW CSC)

Carolyn A.F. Enquist, Deputy Director, DOI SW CSC

Broad-scale Monitoring Workshop * 5-6 April 2016

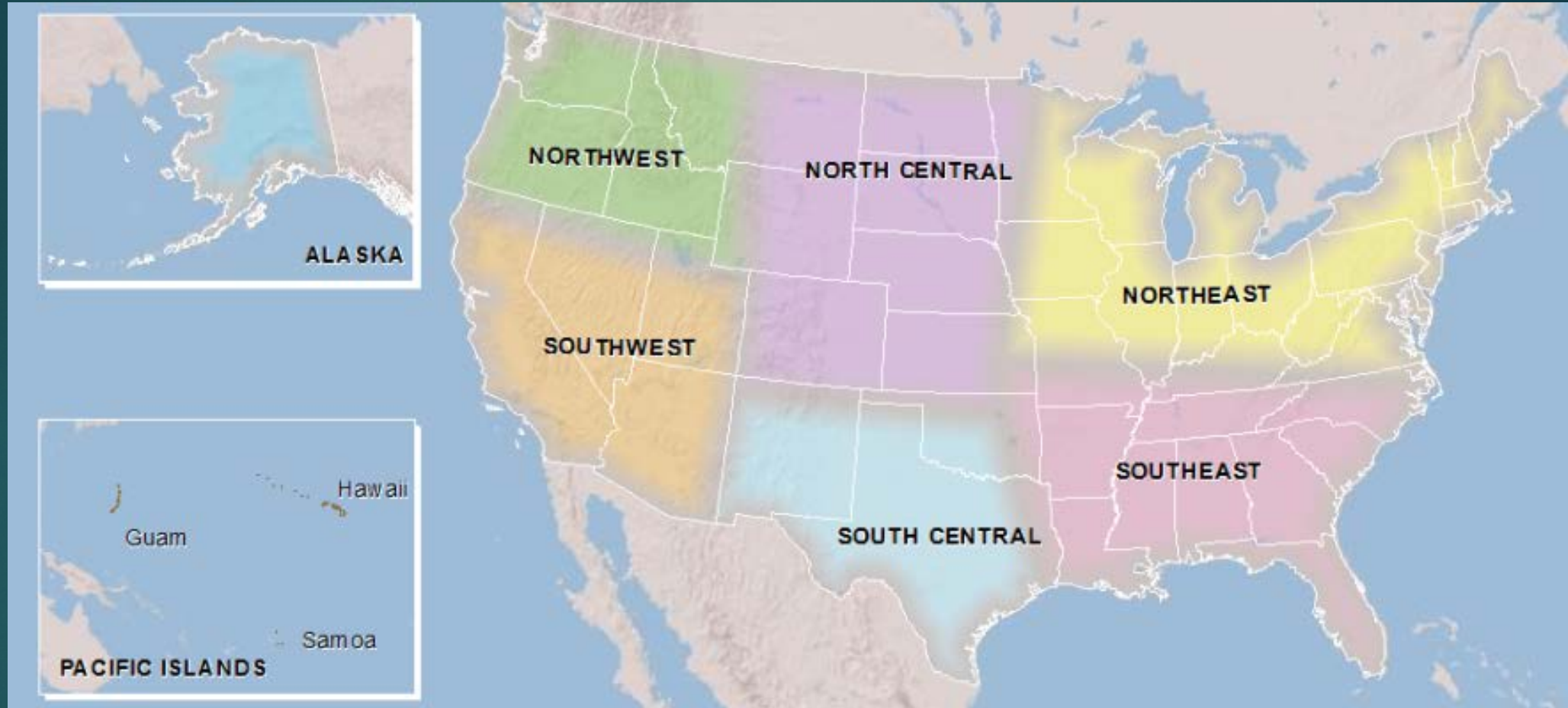
Mission:

To work with natural & cultural resource managers to develop and deliver scientific information, tools, and techniques to anticipate, monitor, and adapt to ongoing climate change.





Southwest Climate
Science Center



8 regional Climate Science Centers established as part of the Department of Interior's "*Plan for a Coordinated, Science-Based Response to Climate Change Impacts*" (**Secretarial Order 3289**).

Vision

Through partnerships:

- Actionable (use-inspired) science is applied to inform decision making regionally and locally
- Effective collaborations between scientists & stakeholders are fostered & facilitated
- We are prepared for ongoing climate & environmental change in the SW & beyond





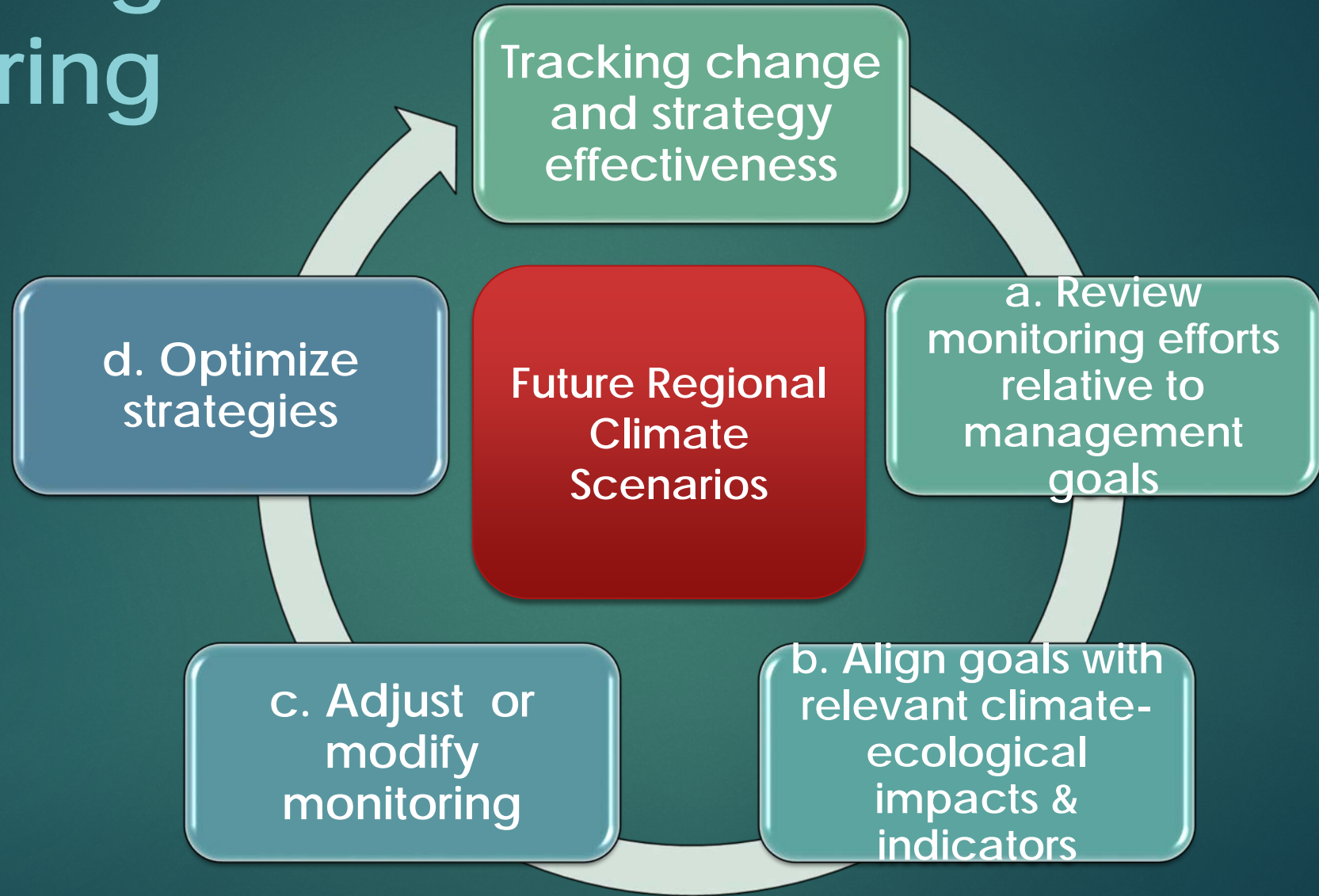
Climate (Smart) Informed Adaptive Management

*Track (monitor)
action effectiveness
& ecological
response*





“Unpacking” monitoring





Climate Informed Monitoring (CIM)

A process to evaluate and optimize existing and identify new efforts relative to climate-informed management goals & objectives; identify gaps & opportunities



Indicators:

Linking Essential Variables

Essential Climate Variable (ECVs)
Temperature (T, Winter Minimum, Summer maximum, mean)
Precipitation (PPT)
Evapotranspiration (ET)
Wind speed (WS)
Surface flow & discharge (SFD)
Groundwater (GD)
Soil moisture (SM)
Relative humidity (RH)

Essential Biological Variables (EBVs)

Pereira et al. 2013

Genetic composition	Allelic diversity
	Co-ancestry
	Population genetic differentiation
	Breed and variety diversity
Species populations	Species distribution
	Population abundance
	Population structure by age/size class
Species traits	Phenology
	Body mass
	Natal dispersal distance
	Migratory behavior
	Demographic traits
	Physiological traits
Community composition	Taxonomic diversity
	Species interactions
Ecosystem structure	Habitat structure
	Ecosystem extent and fragmentation
	Ecosystem composition by functional type
Ecosystem function	Net primary productivity
	Secondary productivity
	Nutrient retention
	Disturbance regime



THANK YOU

Contact Info:

Carolyn A.F. Enquist

Deputy Director

DOI SW Climate Science Center

cenquist@usgs.gov

FIA spatial resolution:

One plot per hexagon

Each hex ~2,400 ha/ 5900 ac

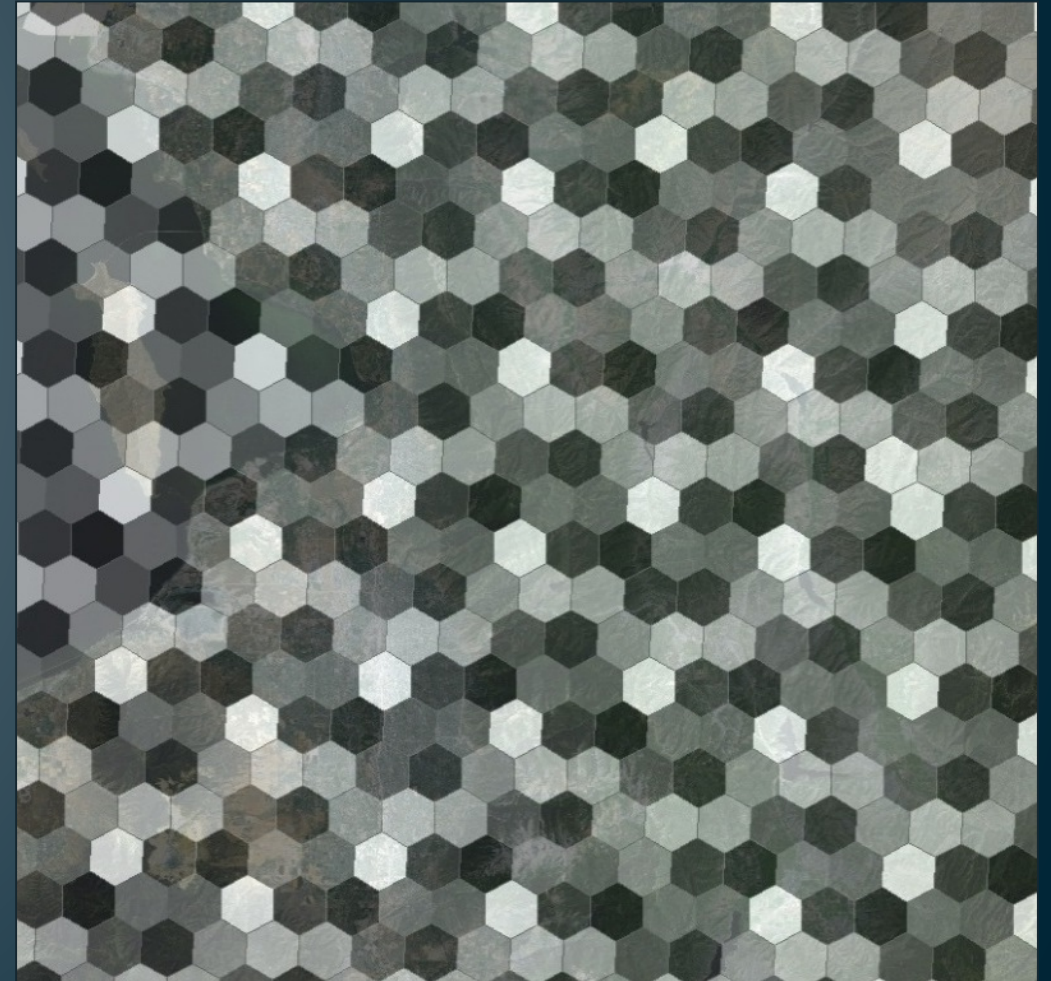
Plots ~3 km apart



FIA temporal resolution:

10% of plot population/year

10 year cycle



Monitoring capabilities:

Species & forest type distribution

Growth and removals

Old growth

Disease

Insect infestations/outbreaks

Snag densities/ retention time

Understory veg composition/structure

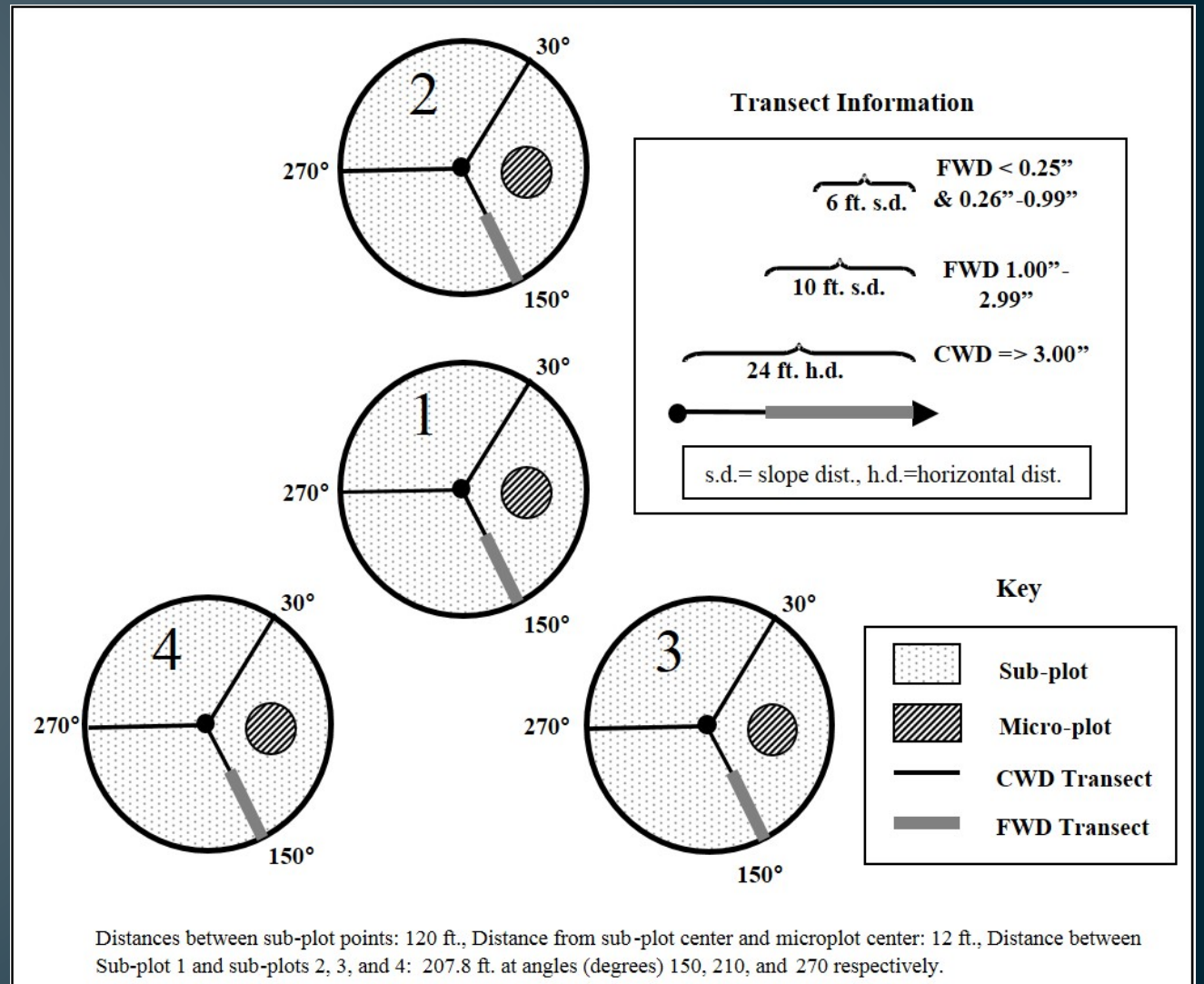
Fuels

Down woody material

Carbon

Wildfire severity and extent

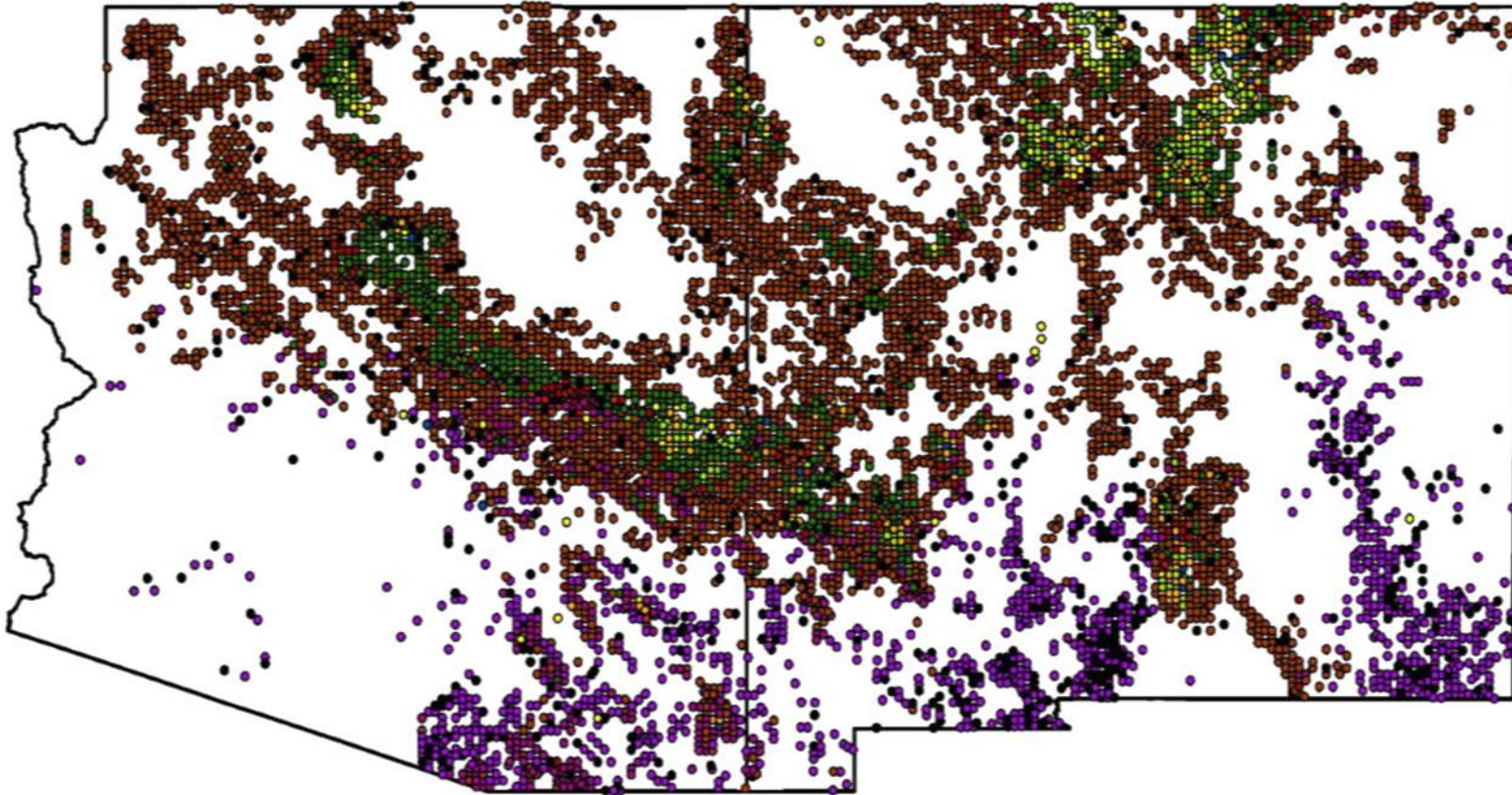
FIA plot layout



Limitations of data access/application

- Estimates with $< 25\%$ error require 20 plots ($\approx 120\text{K}$ acres) of forested land
- **ALL** data are available to the public with the sole exception of exact plot coordinates
- Fuzzed coordinates are provided (50% within $\frac{1}{4}$ mile, 90% within $\frac{1}{2}$ mile)
- Exact location data can be analyzed “in-house” and results provided to user
- Analysts are available to help with query, compilation and interpretation of all data

3,619 (1,476 NFS / 50% re-measured) forested plots in Arizona



4,480 (1,562 NFS / 10% re-measured) forested plots in New Mexico

Critical Management Question 2 (CMQ2) Overview and Status





Critical Management Question 2

- What species and ecological processes are sensitive to climate change and other large scale stressors and/or threats (e.g., water management, invasive species, altered fire regime, wind erosion) and can be effectively monitored to understand the overall effects of these stressors on ecosystems, habitats, and species, thus helping managers detect, understand, and respond to these changes?
- What are the best monitoring designs and protocols to detect changes to these processes and species at temporal and geographic scales suitable for providing adequate and reliable metrics?



CMQ 2: General Stepwise Approach

Steps

1. **Identify stressors/pressures** (that are related to or exacerbated by climate change) using Salafsky (2008)
2. **Prioritize stressors** to focus on.
3. **Identify major ecosystems.**
3. For the highest priority stressors/pressures (13) we **identified sub-stressors** and **developed a questionnaire to rate** each sub-stressors : high, med, low.
4. **Develop a set of criteria** to guide selection of species and/or ecological processes sensitive to the pressures and stressors.
5. Apply the criteria to **select species and/or ecological processes** (for which we will develop monitoring recommendations in a later step).
6. **Develop recommendations for monitoring.**



CMQ 2: General Stepwise Approach

Steps	Status
1. Identify stressors/pressures (that are related to or exacerbated by climate change)	Completed
2. Prioritize stressors to focus on.	Completed
3. Identify major ecosystems	Completed
3. Select subset of highest priority stressors/pressures within each ecosystem to monitor climate impacts (by rating each as high, med, low)	Nearly completed
4. Develop a set of criteria to guide selection of species and/or ecological processes sensitive to the pressures and stressors.	Nearly completed
5. Apply the criteria to select species and/or ecological processes (for which we will develop monitoring recommendations in a later step).	
6. Develop recommendations for monitoring	



Selected Stressors

1. Fires and fire suppression
2. Habitat shifting and alteration - CC
3. Drought -CC
4. Indirect ecosystem effects (fragmentation/ isolation)
5. Temperature extremes - CC
6. Invasive, nonnative/alien species
7. Dams and water management/use
8. Renewable energy
9. Storms and flooding -CC
10. Livestock, farming and ranching
11. Mining and quarrying
12. Logging and wood harvest
13. Agriculture and forestry effluents and pollution



Example of Questionnaire Results

CMQ 2: Summary of High, Medium, and Low Priority Threats

This matrix summarizes high, medium, and low priority threats identified in the CMQ 2 threats survey. Priority level percentages (high, medium, low, not applicable) are based on the total number of people who responded high, medium, low, or not applicable.

	Chihuahuan Desertscrub	Coastal Aquatic Habitats	Madrean Woodland	Mohave Desertscrub	Petran Subalpine and Montane Conifer Forest and Great Basin Conifer Woodland	Plains & Great Basin Grassland	Riparian	Semidesert Grassland	Sinaloan Thornscrub	Sonoran Desertscrub	Springs	Streams
COLOR KEY	≥ 75% responded "high"				≥ 90% responded "high" or "med"			≥ 70% responded "high" or "medium"				

2.3: Livestock, farming, and ranching

Unsustainable grazing

% High	85	33	30	70	0	100	62	58	33	50	45	53
% Med	8	33	30	30	80	0	31	25	67	31	27	41
% Low	8	33	40	0	20	0	8	17	0	19	27	6
% NA	0	0	0	0	0	0	0	0	0	0	0	0
N =	13	6	10	10	5	2	13	12	6	16	11	17

Changes to drought-adapted grazing species (e.g., from cattle to goats or exotics)

% High	27	0	0	40	50	0	29	9	20	38	33	25
% Med	18	50	22	20	0	100	43	36	60	15	33	42
% Low	55	33	56	40	50	0	29	45	20	38	33	33
% NA	0	17	22	0	0	0	0	9	0	8	0	0
N =	11	6	9	5	2	1	7	11	5	13	9	12

Increased groundwater pumping to attempt to maintain farming

% High	69	33	10	60	0	100	85	36	60	44	64	83
% Med	15	67	30	20	75	0	8	9	20	25	36	6
% Low	8	0	50	20	25	0	8	55	20	31	0	11
% NA	8	0	10	0	0	0	0	0	0	0	0	0
N =	13	6	10	10	4	1	13	11	5	16	11	18



Draft Criteria for Select Monitoring Targets

1. Provide information about changes in important processes that are meaningful in the ecosystem of interest.
2. Are sensitive to the stressor of interest, in the ecosystem of interest.
3. Are sensitive enough to detect important changes but not so sensitive that signals are masked by natural variability.
4. Are able to detect changes at appropriate temporal and spatial scales without being overwhelmed by variability.
5. Have a well-understood and accepted known response to the stressor or interest
6. Are anticipatory and can signify impending change in the ecological system
7. Can be measured in a relatively straightforward and cost-effective process.
8. Have broad geographic representation across the habitat/ecosystem type.

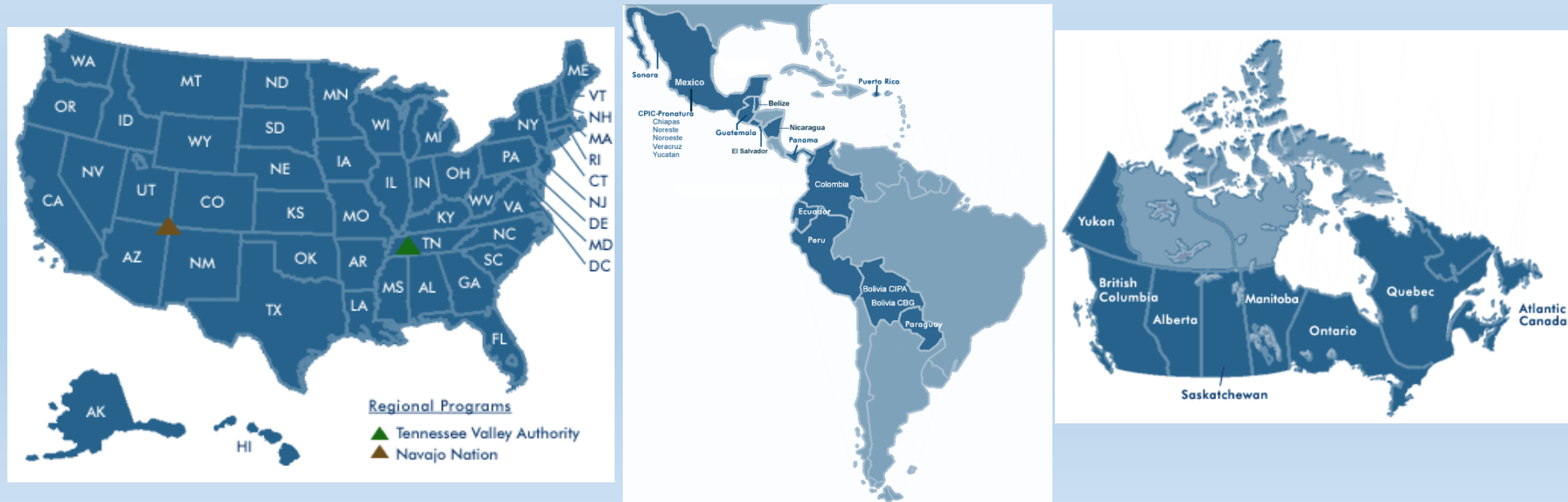


Next Steps

- Finalize hi-med-low ratings with additional questionnaire results
- Finalize criteria for selecting monitoring targets
- Identify monitoring targets for each “cell”
- Identify or develop recommended monitoring protocols
- Initiate pilot trials

Heritage Data Management System (HDMS)

The HDMS is a state-wide central repository of site specific data on special status and rare species and is a member of the NatureServe Network of more than 80 Natural Heritage Programs and Conservation Data Centres, including programs located in Canada, Navajo Nation, Mexico and Latin America. Over 40 years of standards and methods.



GIS/Complex Database

The HDMS is a complex relational and dynamic database and GIS system with data added and corrected daily.

The screenshot displays a complex GIS/Complex Database interface. On the left, a map window titled "Biotics Mapper" shows a map of Flagstaff, Arizona, with various critical habitats overlaid in different colors (green, pink, brown). A legend on the left side of the map lists various critical habitats, such as "Critical Habitat Mt. Grand", "Critical Habitat Huachuca", and "Critical Habitat Virgin Riv". The map is labeled "Flagstaff" in the center.

On the right, a data table titled "Tracker (Element Occurrence)" is displayed. The table lists various elements of occurrence, including Echinocereus hedgehog cactus. The table has columns for ID, ELCODE BCD, EO Number, Subnational Scientific Name, Subnational Common Name, EO Rank, Survey Site, State, Subnation, and Nation. The table is currently working on a list of AZ_hedgehog_cactus.

Below the table, a detailed view of an element occurrence is shown for "NEO - Haliaeetus leucocephalus (wintering pop.) (Element Occurrence Species)". The view includes a summary, higher taxonomy code (VBA001), subnational scientific name (Haliaeetus leucocephalus (wintering pop.)), subnational common name (Bald Eagle - Winter Population), and survey information (Survey Type: Surveys, Survey Date: 2008-01-11, Last Observation Date: 2008-01-11, First Observation Date: 1992-01-10). The EO Data field contains detailed observations: "1992-01-10: Non-roost, 3 adults observed, one perched, one flew upstream and one downstream. 1993-01-09: Non-roost, 1 adult observed. 1995-01-13: Non-roost, 0 birds observed. 1996-01-14: Non-roost, 1 adult observed flying downstream landing in cottonwood, and 1 immature observed soaring above creek landing upstream. 1997-01-11: Non-roost, 3 adults, 1 imm and 1 unknown held male observed. 1998-01-11: Non-roost, 1 adult observed." The view also includes a contacts table and monitoring/research needs sections.

The bottom of the screen shows the Windows taskbar with the start button, several open applications (Microsoft PowerPoint, Tracker (Element...), NEO - Haliaeetus le...), and the system clock showing 11/8/2008 12:30 PM.

How the Data are Used

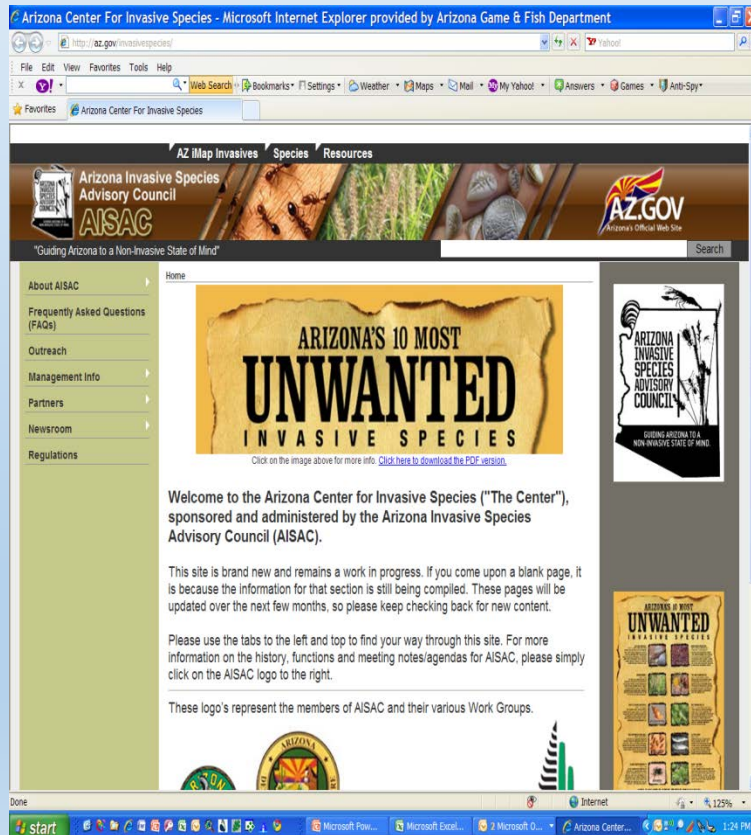
Activities informed by the Heritage Programs include:

- Development Planning: renewable energy, housing, roads, cellular towers, etc.
- Corridor Planning,
- Resource Management Plans,
- Conservation planning,
- Research,
- Land Acquisition
- Public education,
- State and federal regulatory agencies activities, especially for environmental compliance issues
- Diversity Review Meetings - Rankings



Products

Species Abstracts, Management Guidelines, Occurrence Maps, reports of species by location, web sites, collaborative reports, and more.



**ARIZONA GAME AND FISH DEPARTMENT
HERITAGE DATA MANAGEMENT SYSTEM**

Animal Abstract **Element Code:** AFCJC02250
Data Sensitivity: No

CLASSIFICATION, NOMENCLATURE, DESCRIPTION, RANGE

NAME: *Catostomus* sp. 3
COMMON NAME: Little Colorado Sucker, Little Colorado River Sucker
SYNONYMS: *Catostomus latipinnis*
FAMILY: Catostomidae

AUTHOR, PLACE OF PUBLICATION: Minckley, 1971, Keys to native and introduced fishes of Arizona. J. Arizona Acad. Sci., 6:183-188.

TYPE LOCALITY:

TYPE SPECIMEN:

TAXONOMIC UNIQUENESS:

DESCRIPTION: Up to 50.0 cm (19.7 in.) total length and more than 1.0 kg (2.2 lbs.). Body fusiform, chubby and sharply bicolored, with dark gray to blue-black above and white to yellow below in both adults and young (Minckley 1973). Scales large with dorsal scales sharply outlined. Head relatively large, with a long snout and moderately enlarged lower lip. Fleshy lobes on lower lips not produced. Interdorsal membranes of fins typically dark. Lateral line scales 73 to 97, although usually fewer than 90. Dorsal fin-rays 11 or 12 (Minckley 1973).

AIDS TO IDENTIFICATION: Similar to flannelmouth sucker, *C. latipinnis*, though caudal peduncle is thicker and deeper, lower lip is smaller, and distal margin of dorsal fin is slightly falcate to square (Page and Burr 1991).

ILLUSTRATIONS: B&W photo (Minckley 1973:158)
 Color photo (Rinne and Minckley 1991:21)

TOTAL RANGE: Endemic to the upper portion of the Little Colorado River and many of its north flowing tributaries (Coconino, Navajo and Apache Counties). Also introduced into the Salt River.

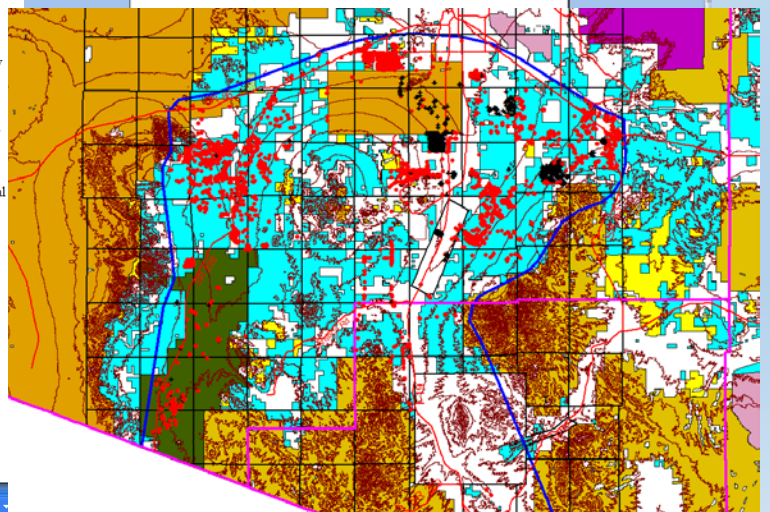
RANGE WITHIN ARIZONA: See "TOTAL RANGE."

upper_verde_39.xls [Compatibility Mode] - Microsoft Excel

Special Status Species within 6 Miles of The Upper Verde River Tract 30

NAME	COMMON NAME	E SA	USFS	BLM STATE
<i>Agosia chrysoptera chrysoptera</i>	Gila Loach Dace	SC	IS	
<i>Catostomus commersoni</i>	Common Sucker	SC	IS	
<i>Catostomus commersoni</i>	Sonoran Sucker	SC	IS	
<i>Coccyzus americanus occidentalis</i>	Western Yellow-billed Cuckoo	SC	IS	WFS
<i>Gila nana</i>	Roundtail Chub	SC	IS	WFS
<i>Haliaeetus leucophaea (swirling pop.)</i>	Bald Eagle		Y, WFS	IS
<i>Melanerpes formicivorus</i>	Scrub Jay	SC	IS	WFS
<i>Melanerpes formicivorus</i>	Scrub Jay	SC	IS	WFS
<i>Myiarchus cinerascens</i>	Grayed Flycatcher	SC	IS	
<i>Pyrocephalus rubine</i>	Blue Jay	SC	IS	
<i>Rhinichthys obtusius</i>	Speckled Grease	SC	IS	IS
<i>Siniperca kneri</i>	Verde Valley Sucker	SC	IS	IS
<i>Siniperca kneri</i>	Rainbow Sucker	SC	IS	WFS

No Critical Habitats in project area.
 Arizona Game and Fish Department, Heritage Data Management System, March 25, 2007



HDMS Web Page

MANAGING TODAY FOR WILDLIFE TOMORROW
www.azgfd.gov

BUY LICENSES | BIG GAME DRAW | eNEWS | CALENDAR | VIDEO | HUNTING | FISHING | WILDLIFE VIEWING | CONSERVATION | EDUCATION | BOATING | SHOOTING | OHV | SITE MAP | EMPLOYMENT

AZGFD HOME

- ONLINE SERVICES
- NEWSROOM
- HUNTING & FISHING
- OUTDOOR RECREATION
- WILDLIFE & CONSERVATION
 - Living with Wildlife
 - Comprehensive Wildlife Conservation Strategy
 - Teaming With Wildlife
 - Conservation & Management
 - Heritage Fund Program
 - Research
 - Technical Reports
 - Wildlife Related Diseases
 - Nongame Species
 - Arizona's Natural Heritage Program (HDMS)
 - Arizona's Natural Heritage
 - What is the HDMS?
 - Products & Services
 - Species Data Lists
 - Plant & Animal Abstracts
 - Contact HDMS
 - Project Evaluation Program (PEP)
 - Economic Impact
 - Special Permits
 - Resources
- INFORMATION & EDUCATION
- INSIDE AZGFD
- FAQS

Arizona's Natural Heritage Program: Heritage Data Management System (HDMS)

The HDMS is part of a global network of more than 80 Natural Heritage Programs and Conservation Data Centres. HDMS information is available so Arizonans can make prudent decisions weighing future development, economic growth, and environmental integrity.

It identifies elements of concern in Arizona and consolidates information about their status and distribution throughout the state.

- On-line Environmental Review Tool
- Arizona's Natural Heritage
- What is the Arizona HDMS?
- Products and Services the HDMS offers
- View Species data lists and status and ranking definitions.
- View Plant and Animal Abstracts, Distribution Maps & Illustrations, sorted by Taxon below:

Amphibians	Invertebrates	Plants
Birds	Mammals	Reptiles
Fish		

Looking for more information?
Our [resources](#) page links to external clubs, associations, government and other Web sites to help you find additional information.

Related AZGFD Info

- On-line Environmental Review Tool
- Sign up for AZGFD eNews
- Watchable Wildlife
- Wildlife News

External Resources [More]

- Natural Resource Conservation Service
- Endangered Species Act

NOTE: External sites will open in a new browser window.

iMapInvasives
gotracking invasive exotic species

Arizona's publicly accessible database. Helping put invasive species data into action.

HDMS Administers the Online Environmental Review Tool

<http://www.azgfd.gov/hgis/> - Microsoft Internet Explorer provided by Arizona Game & Fish Department

Arizona Game & Fish Department
MANAGING TODAY FOR WILDLIFE TOMORROW
www.azgfd.gov

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▼ Projects

- Project Submissions
- Project Submissions (Archived)

▼ Environmental Review

- Environmental Review Layer
- Areas of Capture Concern

▼ Special Areas

- Critical Habitat
- Important Bird Areas
- Special Areas
- Tribal Lands
- Wildlife Corridors

▼ Reference Layers

- AGFD Game Management Units
- AGFD Managed Areas
- AGFD Regions
- Biotic Communities
- BLM District
- BLM Field Offices
- Counties
- Land Ownership

WE'VE UPGRADED! Thank you for your feedback!

Environmental Review On-Line Tool

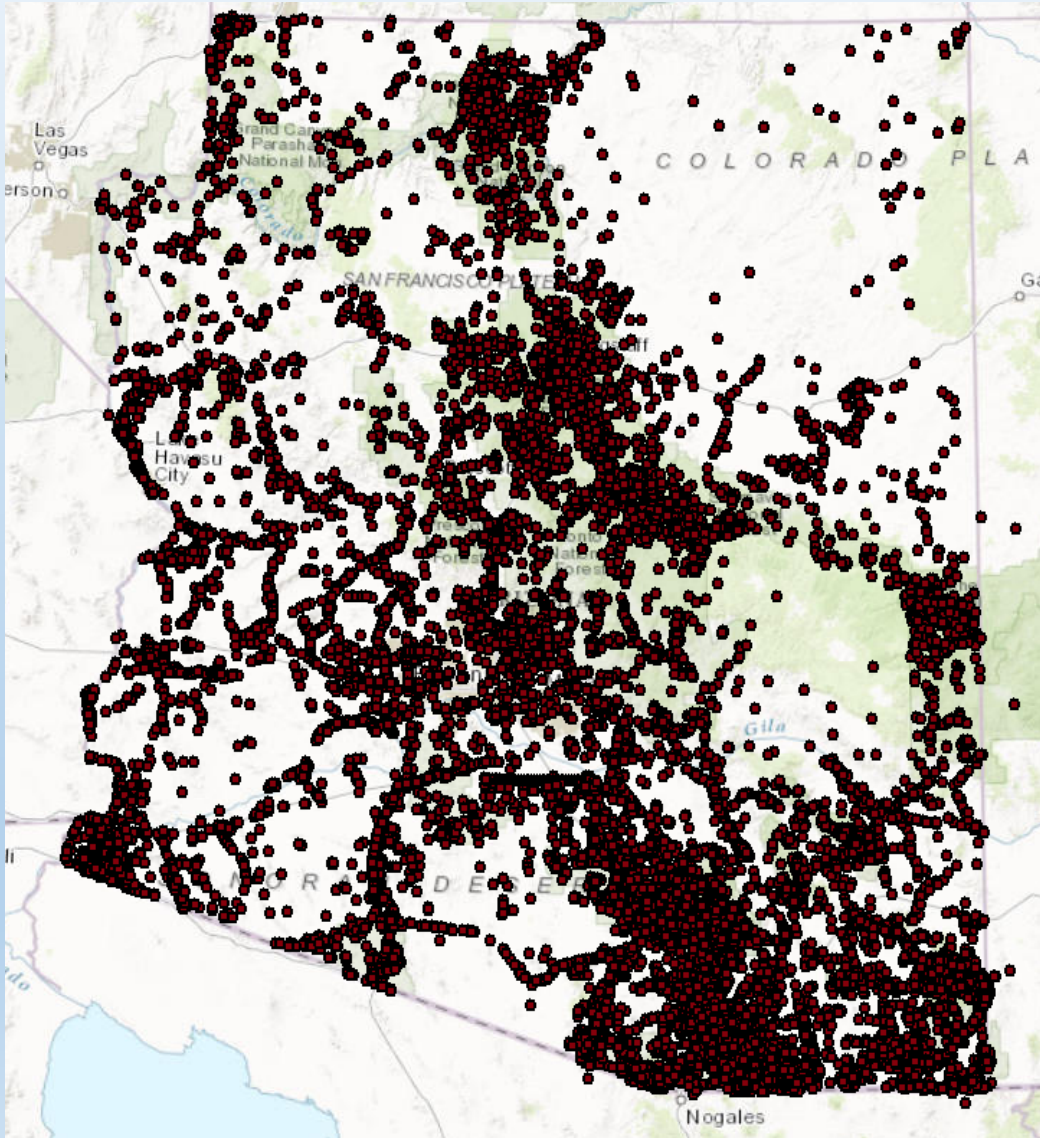
- The Arizona Game and Fish Department's Heritage Evaluation Program (PEP) work together to provide plant and wildlife species location and status to air information can be used to guide preliminary decision development, management, and conservation project resource needs or features.
- If you are developing an environmental document project, and are in need of a special status species the following options:
- If your project is larger than the scope of the on-line tool, you can request a project-specific evaluation.

The *i*MapInvasives Project In Arizona



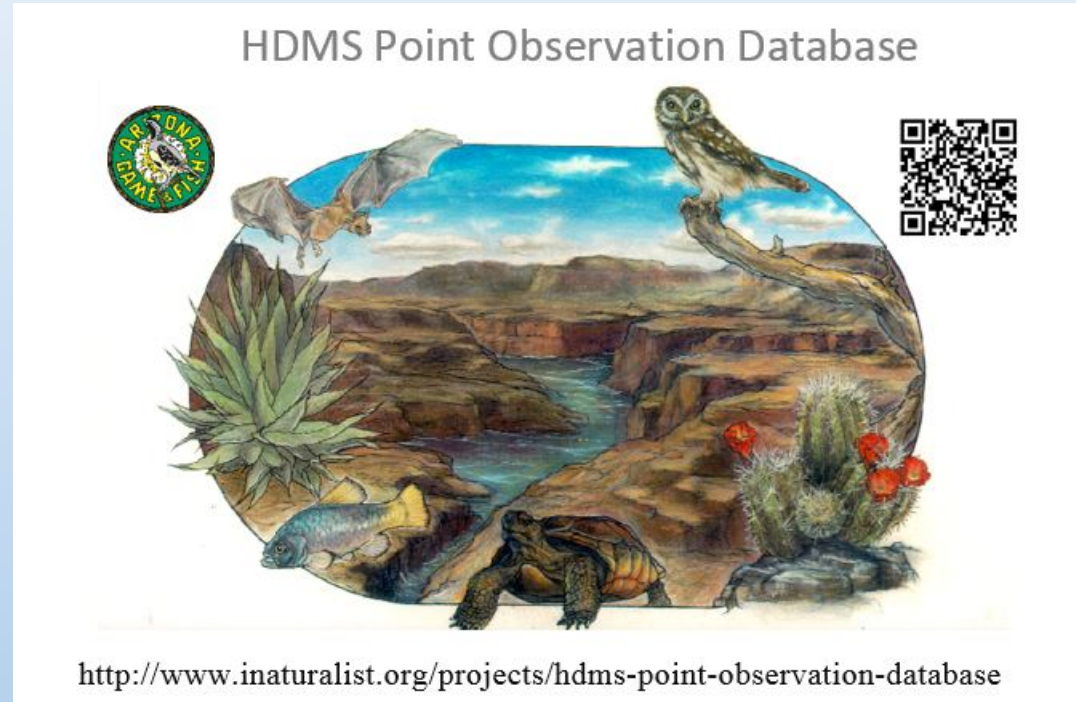
iMapInvasives is an online, interactive, GIS-based mapping tool that aggregates and displays invasive species location data from multiple sources.

HDMS Point Observation Database



- Need for Baseline Data for SWAP
- Started with 16 years of Scientific Collecting Permits
- Added Audubon IBA data
- Herp Data from selected individuals
- Currently have 300,000 points
- Starting Citizen Science Project on iNaturalist

HDMS Point Observation Database



Project through iNaturalist to collect observations from Citizen Scientist to add to Scientific Collecting Permits and other sources for all species.

Data Sharing

- State Laws Limit some sharing – land owners always have the rights
- MOU with HDMS and R3 USFS & NHNM
- Provide data as requested with Forests and Ranger Districts
- As technology has advanced, sharing has diminished

Data Limitations

- Information Currentness
- Information Sensitivity
- Need for Interpretation of Information
- Data Serves as a Guide - absence of data does not equate to absence of a species
- Taxonomy reconciliation with other data sets

Wildlife Applications for the Forest Inventory and Analysis program

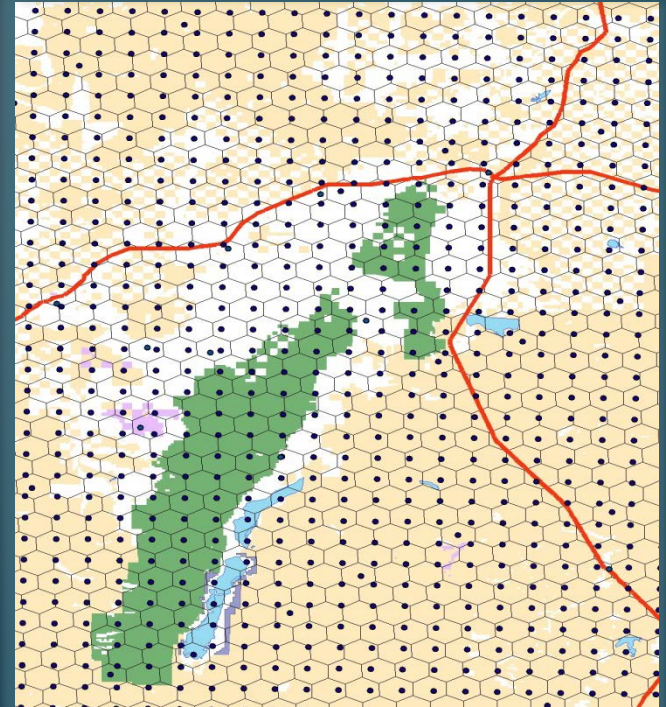
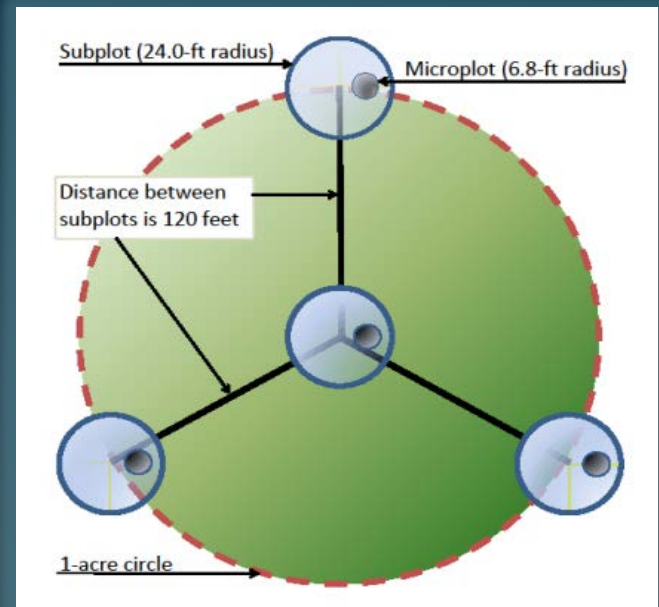
Chris Witt, Ecologist, USFS Rocky Mountain Research Station, Forest Inventory and Analysis program



What we do...

Nation's Forest Census

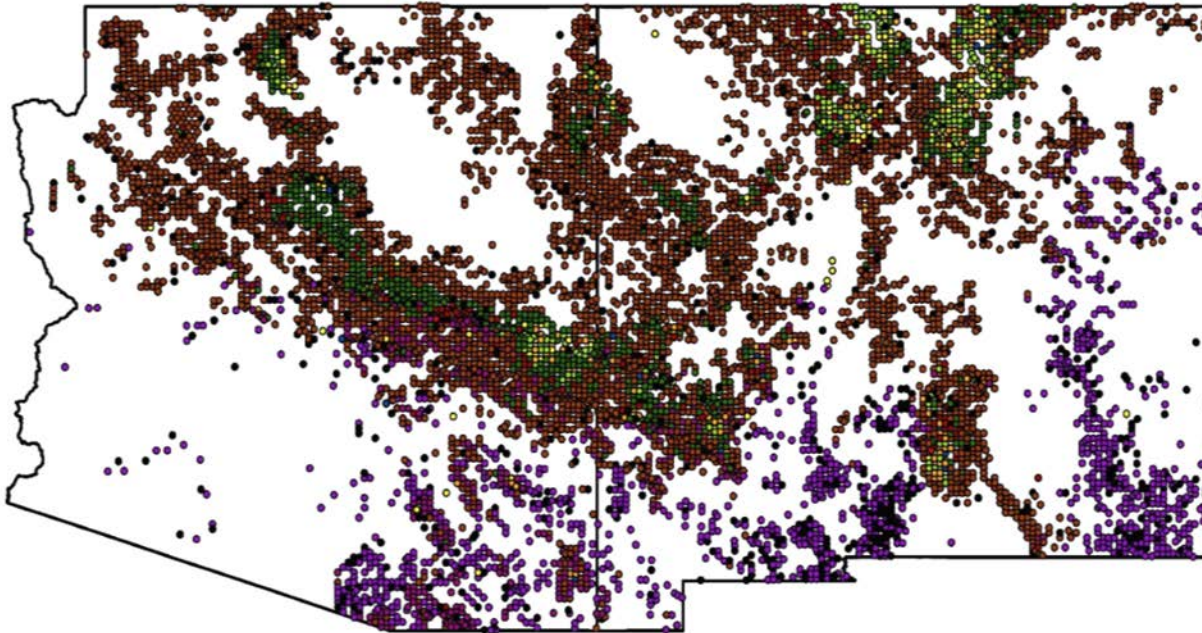
- Across all ownerships
- Plots located on grid \approx 1 plot per 6000 acres
- 10 percent of a state's plots are visited (revisited) each year
- $>$ 120 forest/tree attributes measured
- Provide area estimates and trends at landscape scales



Where we go...

- All forest lands in U.S.
- 8,099 forested plots in Region 3

3,619 (1,476 NFS) forested plots in Arizona



4,480 (1,562 NFS) forested plots in New Mexico

What we measure...

Plot-level attributes

- forest type
- stand-age
- ownership
- tree cover by layer
- canopy cover
- basal area
- elevation
- Aspect

Examples – mule deer winter range, lynx dens, pinyon jay habitat

Tree-level attributes

- diameter
- height
- status
- decay class
- species
- disease
- annual growth

Examples- fisher dens, bat roosts, cavity-nesting birds

What we measure...

Understory vegetation

- Cover of most common (up to four) species of:
 - Trees
 - Shrubs
 - Graminiod
 - forbs
- Cover of each of the growth habits by layer
- Aerial cover of each growth habit

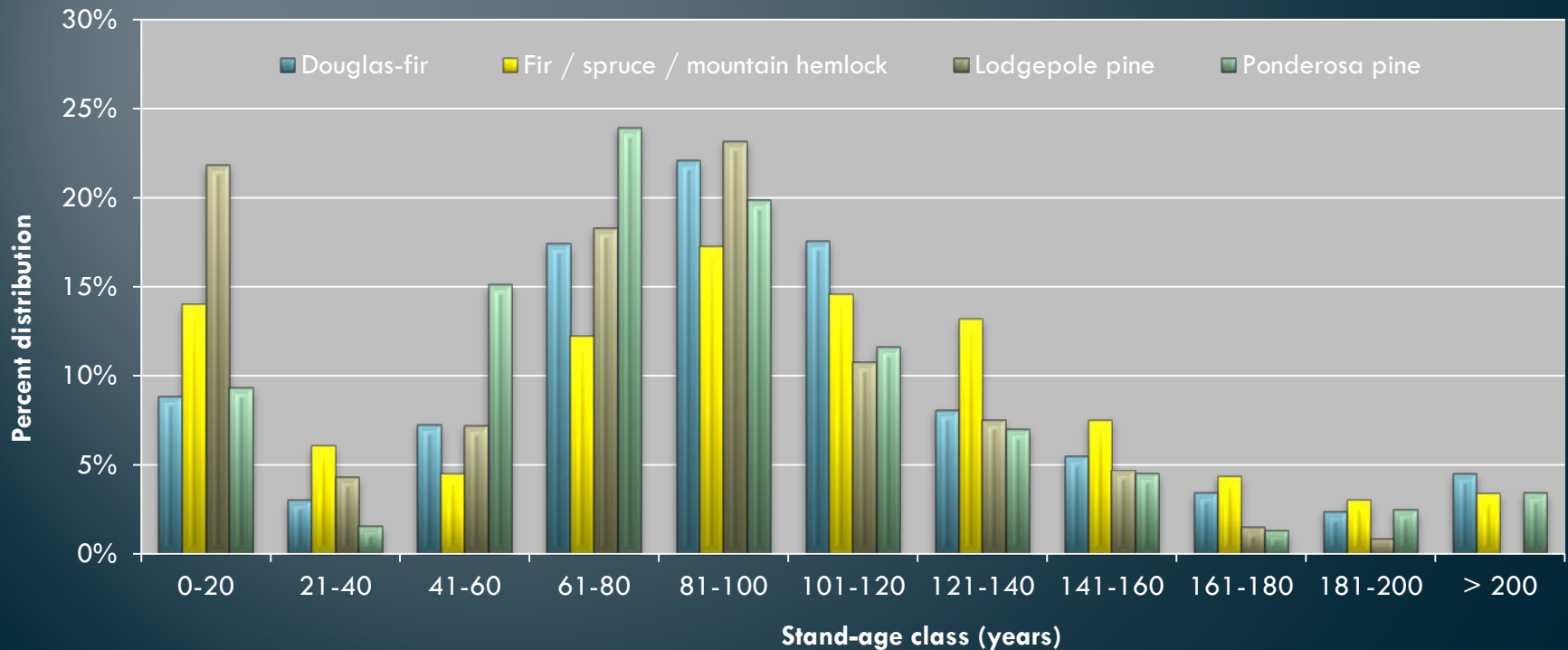
Down woody material

- Mean number of logs $> 3''$ d.b.h.
- Mean cover of fine woody material (3 size classes $< 3'$ d.b.h.)
- Mean depth of litter and duff

How we use it...

Population-level estimates:

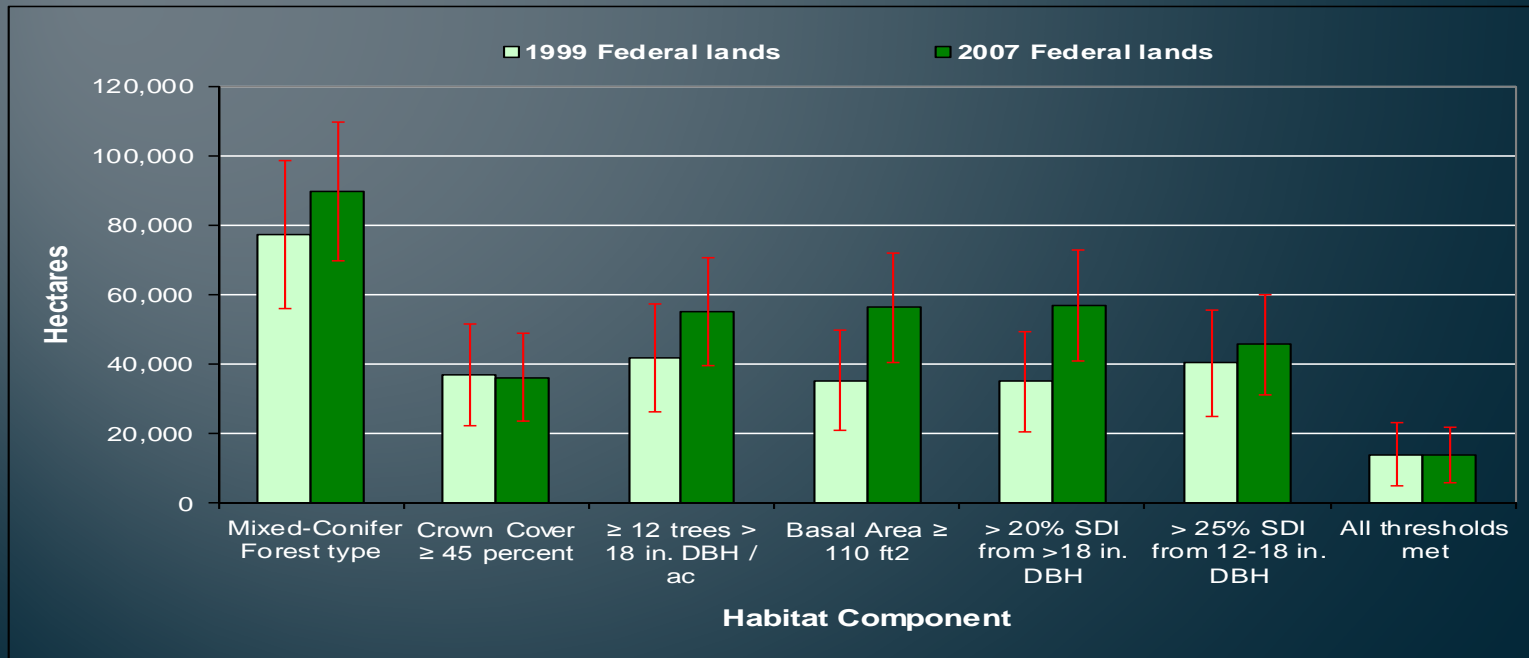
- Quantifying resources at the level of a Forest District, County, or State.
- Tracking forest health, disturbance, growth and removals



How we use it...

Monitoring:

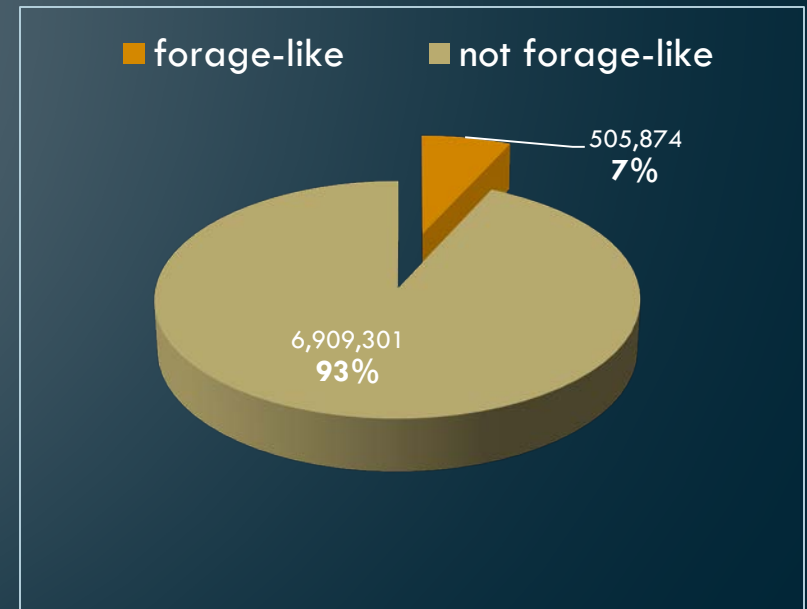
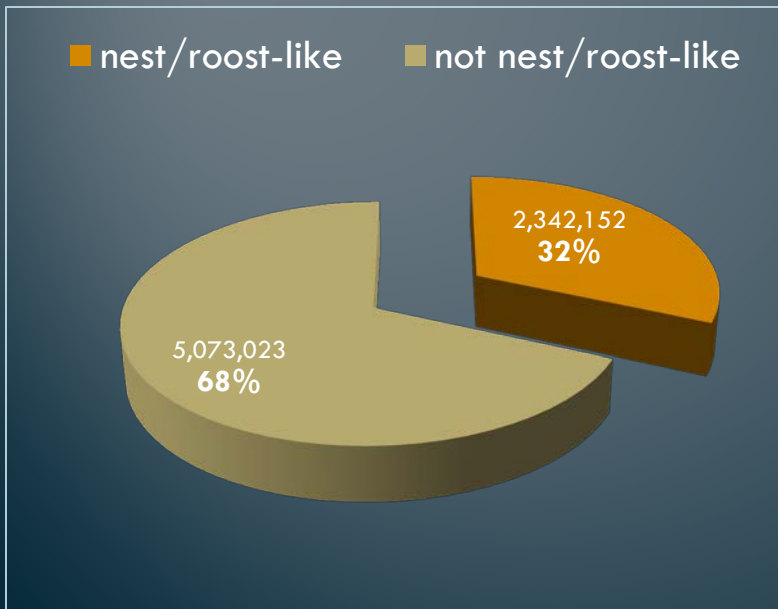
- Tracking changes in resources over time
- Assessing effectiveness of management plans



How we use it...

Habitat assessment:

- Quantifying habitat at landscape scales
- Identifying limiting resources



Where is the data?

- Data portals are at:

<http://www.fia.fs.fed.us/tools-data/default.asp>

USDA FOREST SERVICE

Forest Service National Links

Forest Inventory and Analysis National Program

(enter query) Search

U.S. Forest Service
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Program Features
FIA Data and Tools
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Other Data
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Links
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We welcome your comments on our service and your suggestions for improvement.

Forest Inventory & Analysis
National Office
U.S. Forest Service
1601 North Kent Street,
Suite 400
Arlington, VA 22209

Data and Tools

Click here for the latest user alerts.

FIDO	Forest Inventory Data Online – Create your own forest inventory tables and maps.
EVALIDator	This program allows users to produce a large variety of population estimates and their sampling errors based on the current FIADB.
FIA DataMart	Download raw data, Microsoft Access databases, FIADB Users Manuals, and access standard tables and recent data load history.
Other Reporting Tools	Create reports and maps using other online tools, including the Timber Products Output (TPO) Reporting tool, and the National Woodland Owner Survey Table Maker. A link to the Forest Vegetation Simulator (FVS) pre-processor tool for FIA data.
Training and Tutorials	Learn how to use our online tools through presentations, example exercises and tutorials. Sign up for the next scheduled training session.

- Assistance with data access and analysis:

chriswitt@fs.fed.us (208) 373-4370