Vital Signs Monitoring in Yellowstone, Bighorn Canyon & Grand Teton National Parks

Results of Round 2 of a Delphi Survey

A Survey of Scientists & Resource Professionals

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An Overview of Round 2 of the Vital Signs Monitoring Delphi Survey

Overall, the project involves three rounds of questions that progress from very general to more specific. In the first round (**Round 1**), we asked resource experts to identify what they consider to be the most important resource components, conditions, or processes that should be monitored. The results have been used to compile a comprehensive list. Now in this survey, **Round 2**, we ask you to rank order these based upon what you think are the best things to monitor. In the final round, those indicators emerging as the top priorities within each resource area will be systematically evaluated according to criteria of what constitutes a good indicator for the Vital Signs Monitoring program.

Vital Signs Monitoring: The goal of "Vital Signs" monitoring is to be able to assess the basic health or integrity of park ecosystems and to be able to formulate management actions whenever necessary to maintain the integrity of those ecosystems.

You can be assured of complete confidentiality. The data you submit will be summarized and your name will not be associated with any of your answers.

How are we using terminology?

Monitoring: Monitoring involves carefully designed programs intended to track and evaluate the condition of specifically designated resources. Natural resource monitoring is conducted to:

1. Detect significant changes in resource abundance, condition, population structure, or ecological processes;
2. Develop information on linkages between changes in resource conditions and their causes;
3. Provide field validation for and modeling efforts associated with monitoring; and
4. Evaluate the effects of some management action on population or community dynamics or ecological processes.

Vital Signs are key elements that indicate the health of an ecosystem. Vital signs may occur at any level of organization including **landscape, community, population** or **genetic** levels. They may be

compositional (based upon constituent elements of the system), **structural** (based upon the organization of the system), or **functional** (based upon ecological processes).

Vital signs can be any measurable feature of the environment that provides insights into the state of the ecosystem. They are things that:

- Identify status and trends of ecosystem health
- Define normal limits of variation
- Provide early warning of situations that require intervention
- Suggest remedial treatments and frame research hypotheses
- Determine compliance with laws and regulations

Results

The survey was conducted entirely via Internet and was sent to scientists who had previously held permits to conduct research in any of the three parks, to natural resource agency professionals, and to National Park Service employees nominated by the advisory committee. The survey was initially sent out in mid December of 2001. Unfortunately, soon after that, the Department of Interior was disconnected from all access to the Internet because of pending litigation. This caused about a four-month delay. It is not known how much this affected the response to Round 2 of the Delphi Survey.

The results are presented in the tables and charts that follow. For each of the five major categories (Physical Resources, Aquatic Resources, Vegetation Resources, Vertebrate Species, and Invertebrate Species) respondents were asked to select the five best things to monitor to assess the condition and trend of ecosystems in Bighorn Canyon, Grand Teton, and Yellowstone National Parks. The questions are presented as they appeared in the survey with data entered where the check-off boxes appeared in the original survey. To help the reader quickly see which items were ranked highest (and lowest) each of the five sections is followed by a bar graph which visually depicts how many times each item was selected.

Three additional tables present written comments that respondents submitted on the survey. In Table 1, respondents were asked, "Are there any other resource components or ecosystem processes that you think should be monitored to assess the condition and trend of ecosystems in these national parks?" The table contains in the first column a row number which is just an identification number from each consecutive survey received. The second column displays the other resource components or ecosystem processes they nominated, followed by reasons for selection as an important monitoring priority. In the last three columns, respondents could check whether their comments applied to Yellowstone, Grand Teton, or Bighorn Canyon National Parks. A number one (1) in the column means the comment applies to that park; a blank means that the comment does not particularly to that park. Table 2 presents additional comments that respondents wrote in for each of the five resource categories, particularly if they thought some of the indicators they ranked applied specifically to one of the three parks. Finally, Table 3 presents "Other suggestions concerning vital signs monitoring in Bighorn Canyon, Grand Teton, or Yellowstone National Parks" that respondents entered at the end of the on-line survey.

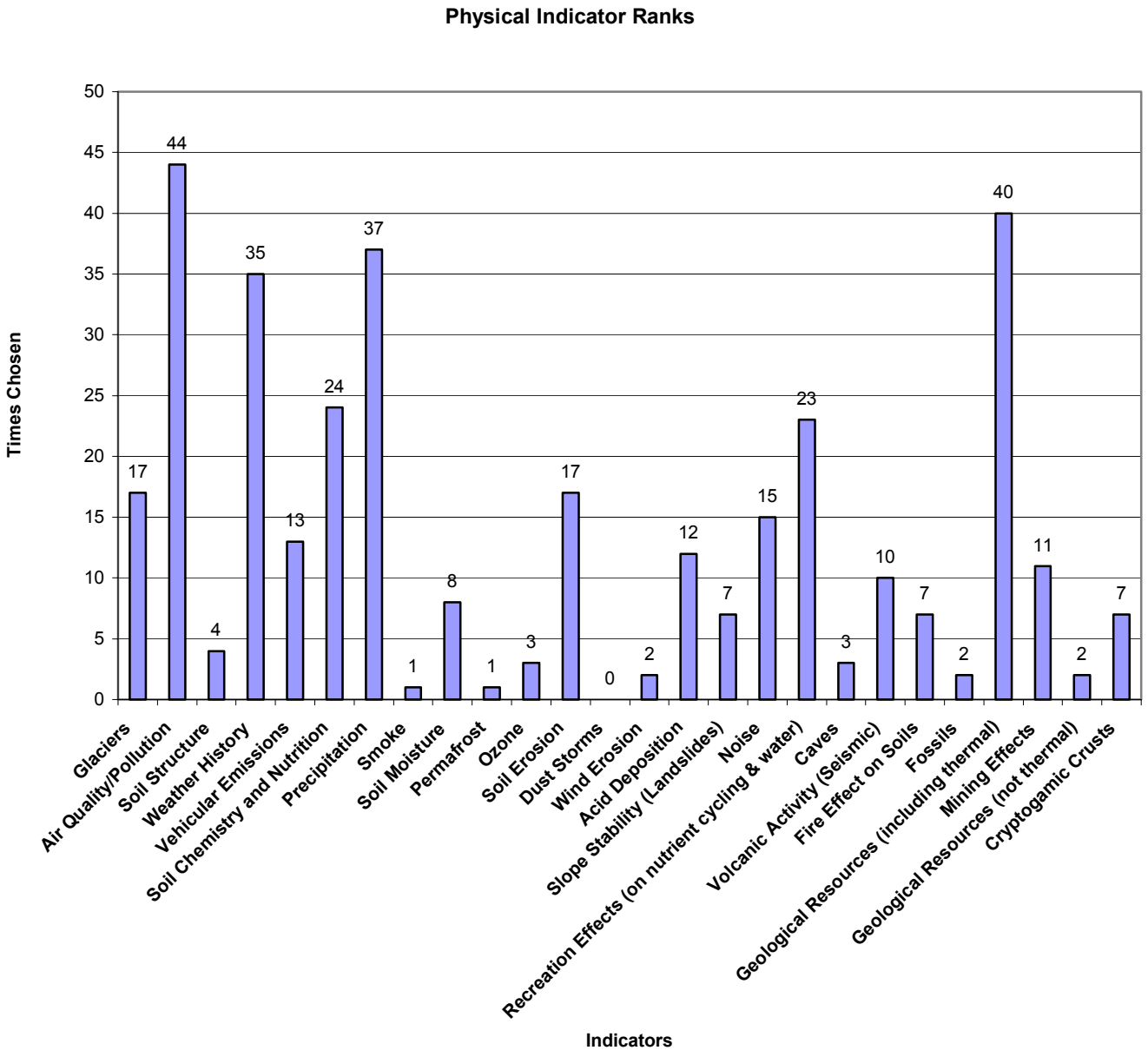
1. PHYSICAL RESOURCES (including air, soil, geology)

Based upon your knowledge and expertise, please select the five best physical indicator topics to monitor the vital signs of these parks.

Please check no more than 5 indicator topics below by clicking to mark or unmark 5 boxes.

Choose only 5:

Number of Votes		Number of Votes		Number of Votes	
	Climate-related		**Air**		**Soil**
17	Glaciers	44	Air quality/pollution	4	Soil Structure
35	Weather history	13	Vehicular emissions	24	Soil chemistry & nutrition
37	Precipitation	1	Smoke	8	Soil Moisture
1	Permafrost	3	Ozone	17	Soil erosion
		0	Dust storms	2	Wind erosion
	Other	12	Acid deposition	7	Slope stability (landslides)
15	Noise		**Geological**	23	Recreation effects (on nutrient cycling & water)
3	Caves	10	Volcanic activity (seismic)	7	Fire effects on soils
2	Fossils	40	Geological resources (including thermal)	11	Mining effects
		2	Geological resources (not thermal)	7	Cryptogamic crusts
18	*I do not have enough expertise to select aquatic indicator topics.*				


Physical Indicator Ranks
Times Chosen
Indicators
0
5
10
15
20
25
30
35
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45
50
17
44
4
35
13
24
37
1
8
1
3
17
0
2
12
7
15
23
3
10
7
2
40
11
2
7
Glaciers
Air Quality/Pollution
Soil Structure
Weather History
Vehicular Emissions
Soil Chemistry and Nutrition
Precipitation
Smoke
Soil Moisture
Permafrost
Ozone
Soil Erosion
Dust Storms
Wind Erosion
Acid Deposition
Slope Stability (Landslides)
Noise
Recreation Effects (on nutrient cycling & water)
Caves
Volcanic Activity (Seismic)
Fire Effect on Soils
Fossils
Geological Resources (including thermal)
Mining Effects
Geological Resources (not thermal)
Cryptogamic Crusts

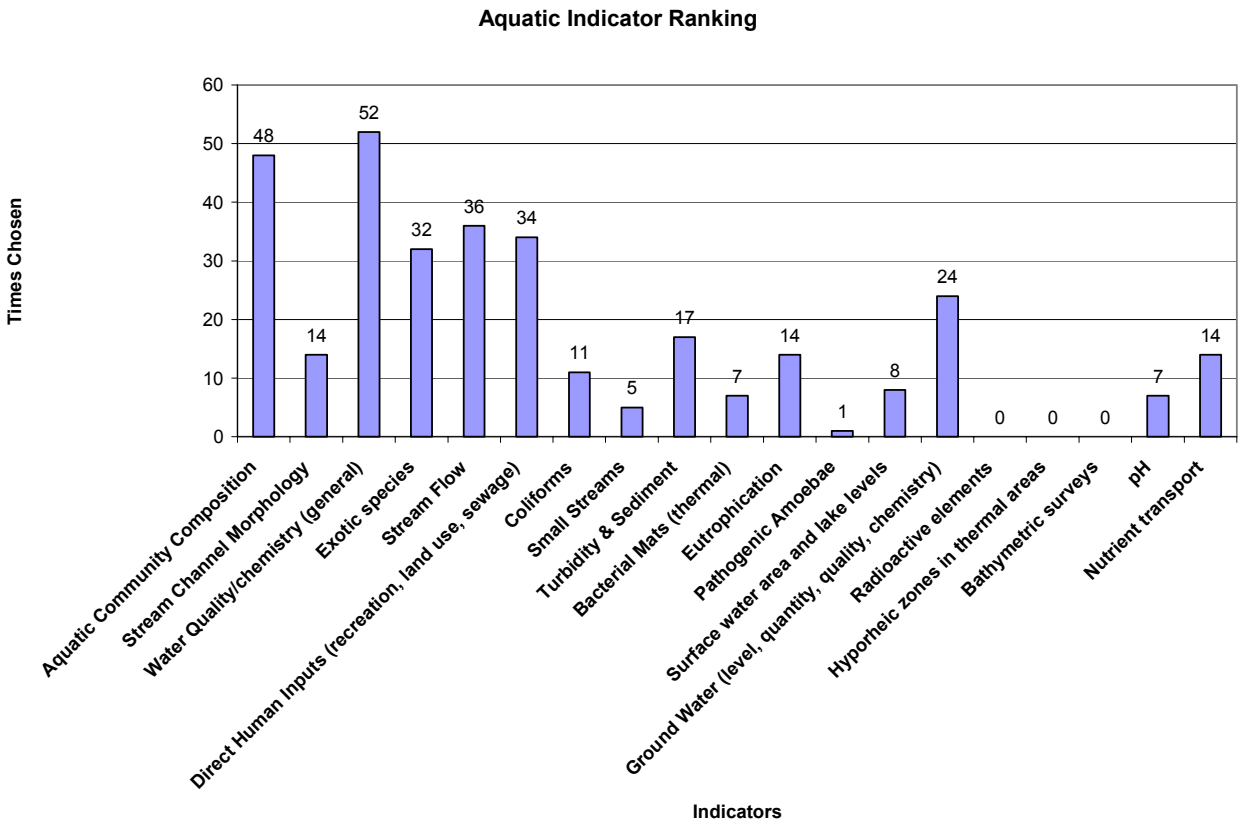
2. AQUATIC RESOURCES (including water quality)

Based upon your knowledge and expertise, please select the five best aquatic indicator topics to monitor the vital signs of these parks.

Please check no more than 5 indicator topics below by clicking to mark or unmark 5 boxes.

Choose only 5:

Number of Votes		Number of Votes		Number of Votes	
	Aquatic Organisms		**Streams**		**General**
48	Aquatic community composition	14	Stream channel morphology	52	Water quality/chemistry (general)
32	Exotic species	36	Stream flow	34	Direct human inputs (recreation, land use, sewage, etc.)
11	Coliforms	5	Small streams	17	Turbidity & sediment
7	Bacterial mats (geothermal)			14	Eutrophication
1	Pathogenic amoebae			8	Surface water area & lake levels
				24	Ground water (level, quantity, quality, chemistry)
				0	Radioactive elements
				0	Hyporheic zones in thermal areas
				0	Bathymetric surveys
				7	pH
				14	Nutrient transport
14	*I do not have enough expertise to select aquatic indicator topics.*				


Aquatic Indicator Ranking
Times Chosen
60
50
40
30
20
10
0
48
14
52
32
36
34
11
5
17
7
14
1
8
24
0
0
0
7
14
Aquatic Community Composition
Stream Channel Morphology
Water Quality/chemistry (general)
Exotic species
Stream Flow
Direct Human Inputs (recreation, land use, sewage)
Coliforms
Small Streams
Turbidity & Sediment
Bacterial Mats (thermal)
Eutrophication
Pathogenic Amoebae
Surface water area and lake levels
Ground Water (level, quantity, quality, chemistry)
Radioactive elements
Hyporheic zones in thermal areas
Bathymetric surveys
pH
Nutrient transport
Indicators

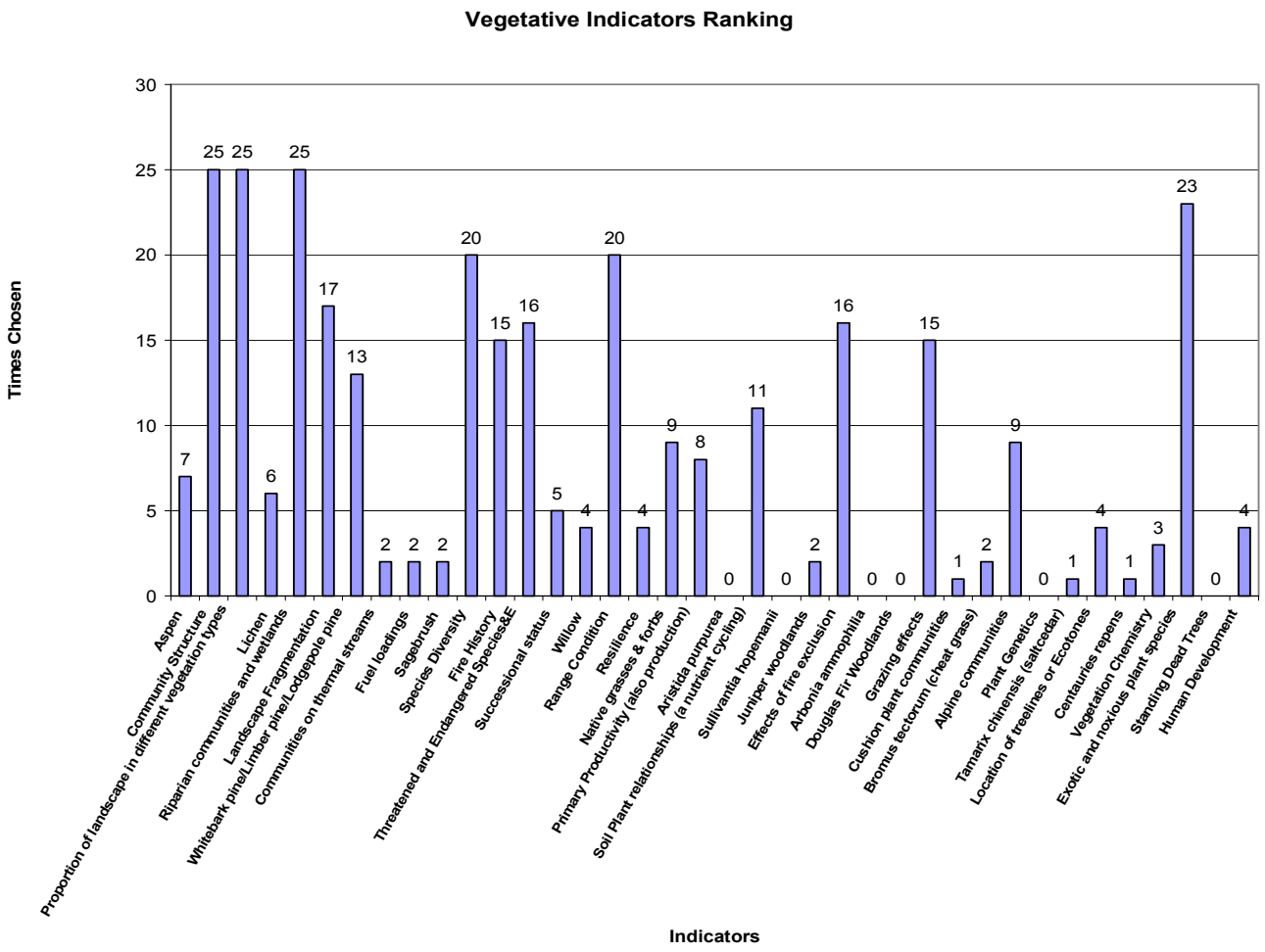
3. VEGETATION RESOURCES

Based upon your knowledge and expertise, please select the five best vegetation indicator topics to monitor the vital signs of these parks.

Please check no more than 5 indicator topics below by clicking to mark or unmark 5 boxes.

Choose only 5:

Number of Votes		Number of Votes		Number of Votes	
	Individual Species		**Communities**		**Landscape elements**
7	Aspen	25	Community structure	25	Proportion of landscape in different veg types
6	Lichen	25	Riparian communities & wetlands	17	Landscape fragmentation
13	Whitebark pine / Limber pine /Lodgepole pine	2	Communities on thermal streams	2	Fuel loadings
2	Sagebrush	20	Species diversity	15	Fire history
16	Threatened & Endangered Spp	5	Successional status		**Processes/functions**
4	Willow		Range condition	4	Resilience
9	Native grasses & forbs			8	Primary productivity (also forage production)
0	Aristida purpurea		**Specific communities**	11	Soil-plant relationships (also nutrient cycling)
0	Sullivantia hopemanii	2	Juniper woodlands	16	Effects of fire exclusion
0	Arbonia ammophila	0	Douglas fir woodlands	15	Grazing effects
	Specific exotic species	1	Cushion plant communities		**Other**
2	Bromus tectorum (cheat grass)	9	Alpine communities	0	Plant genetics
1	Tamarix chinensis (saltcedar)			4	Location of treelines or ecotones
1	Centauries repens			3	Vegetation chemistry
23	**General** Exotic and noxious plant species			0	Standing dead trees
				4	Human Development
18	*I do not have enough expertise to select vegetative indicator topics.*				


Vegetative Indicators Ranking
Times Chosen
Indicators
0
5
10
15
20
25
30
7
25
25
6
25
17
13
2
2
2
20
15
16
5
4
20
4
9
8
0
11
0
2
16
0
0
15
1
2
9
0
1
4
1
3
23
0
4
Aspen
Community Structure
Proportion of landscape in different vegetation types
Lichen
Riparian communities and wetlands
Landscape Fragmentation
Whitebark pine/Limber pine/Lodgepole pine
Communities on thermal streams
Fuel loadings
Sagebrush
Species Diversity
Fire History
Threatened and Endangered Species&E
Successional status
Willow
Range Condition
Resilience
Native grasses & forbs
Primary Productivity (also production)
Aristida purpurea
Soil Plant relationships (a nutrient cycling)
Sullivantia hopemanii
Juniper woodlands
Effects of fire exclusion
Arbonia ammophilia
Douglas Fir Woodlands
Grazing effects
Cushion plant communities
Bromus tectorum (cheat grass)
Alpine communities
Plant Genetics
Tamarix chinensis (saltcedar)
Location of treelines or Ecotones
Centauries repens
Vegetation Chemistry
Exotic and noxious plant species
Standing Dead Trees
Human Development

4.

VERTEBRATE SPECIES

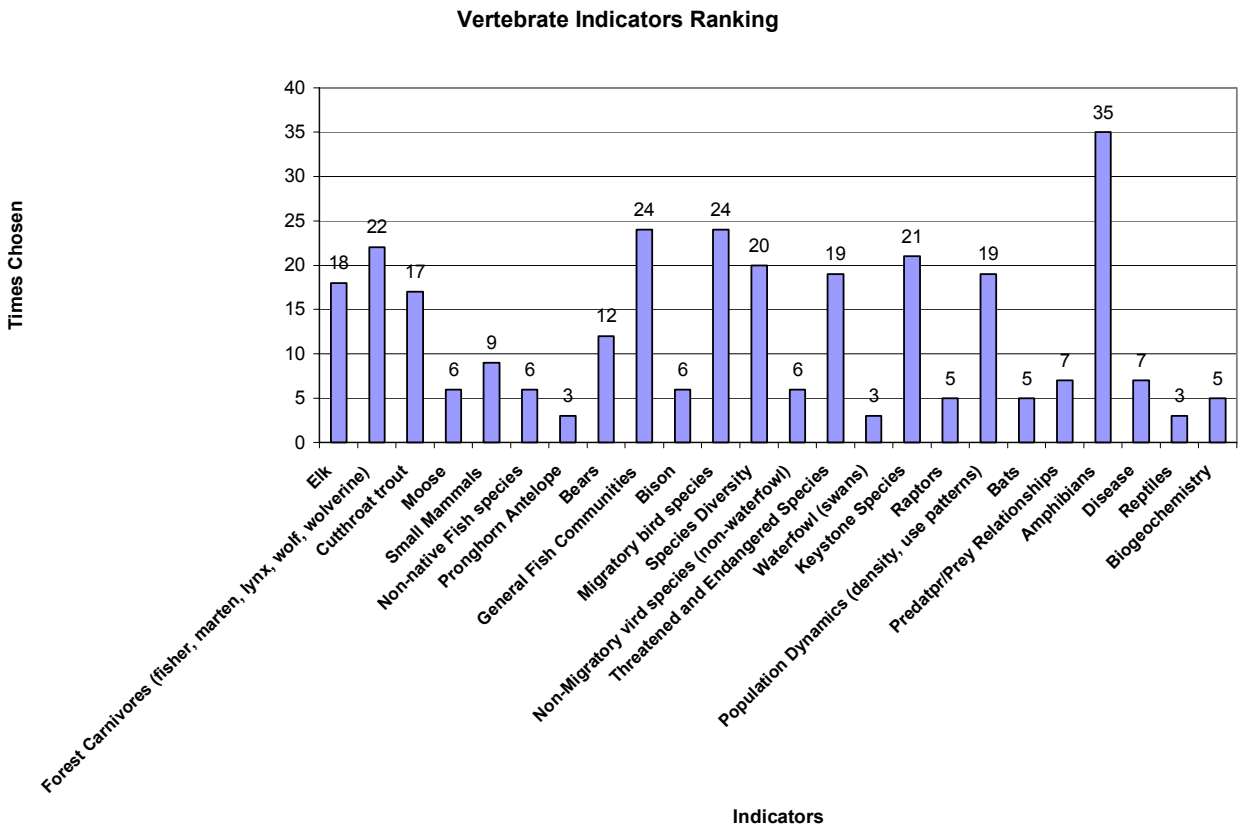
Based upon your knowledge and expertise, please select the five best vertebrate species indicator topics to monitor the vital signs of these parks.

Please check no more than 5 indicator topics below by clicking to mark or unmark 5 boxes.

Choose only 5:

Number of Votes		Number of Votes		Number of Votes	
	Ungulates		**Non-ungulate Mammals**		**Fish**
18	Elk	22	Forest carnivores (fisher, marten, lynx, wolf, wolverine)	17	Cutthroat trout
6	Moose	9	Small mammals	6	Non-native fish species
3	Pronghorn antelope	12	Bears	24	General fish communities
					Other Vertebrate
6	Bison	24	Migratory bird species	20	Species diversity
21	Bighorn sheep	6	Non-migratory bird species (non-waterfowl)	19	Threatened & endangered species
		3	Waterfowl (swans)	21	Keystone species
		5	Raptors	19	Population dynamics (density, use patterns)
	Herps	5	Bats	7	Predator/Prey relationships
35	Amphibians			7	Disease
3	Reptiles			5	Biogeochemistry

19	*I do not have enough expertise to select vertebrate species indicator topics.*


Vertebrate Indicators Ranking
Times Chosen
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5
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22
17
6
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6
3
12
24
6
24
20
6
19
3
21
5
19
5
7
35
7
3
5
Elk
Forest Carnivores (fisher, marten, lynx, wolf, wolverine)
Cutthroat trout
Moose
Small Mammals
Non-native Fish species
Pronghorn Antelope
Bears
General Fish Communities
Bison
Migratory bird species
Species Diversity
Non-Migratory vird species (non-waterfowl)
Threatened and Endangered Species
Waterfowl (swans)
Keystone Species
Raptors
Population Dynamics (density, use patterns)
Bats
Predatpr/Prey Relationships
Amphibians
Disease
Reptiles
Biogeochemistry
Indicators

5.

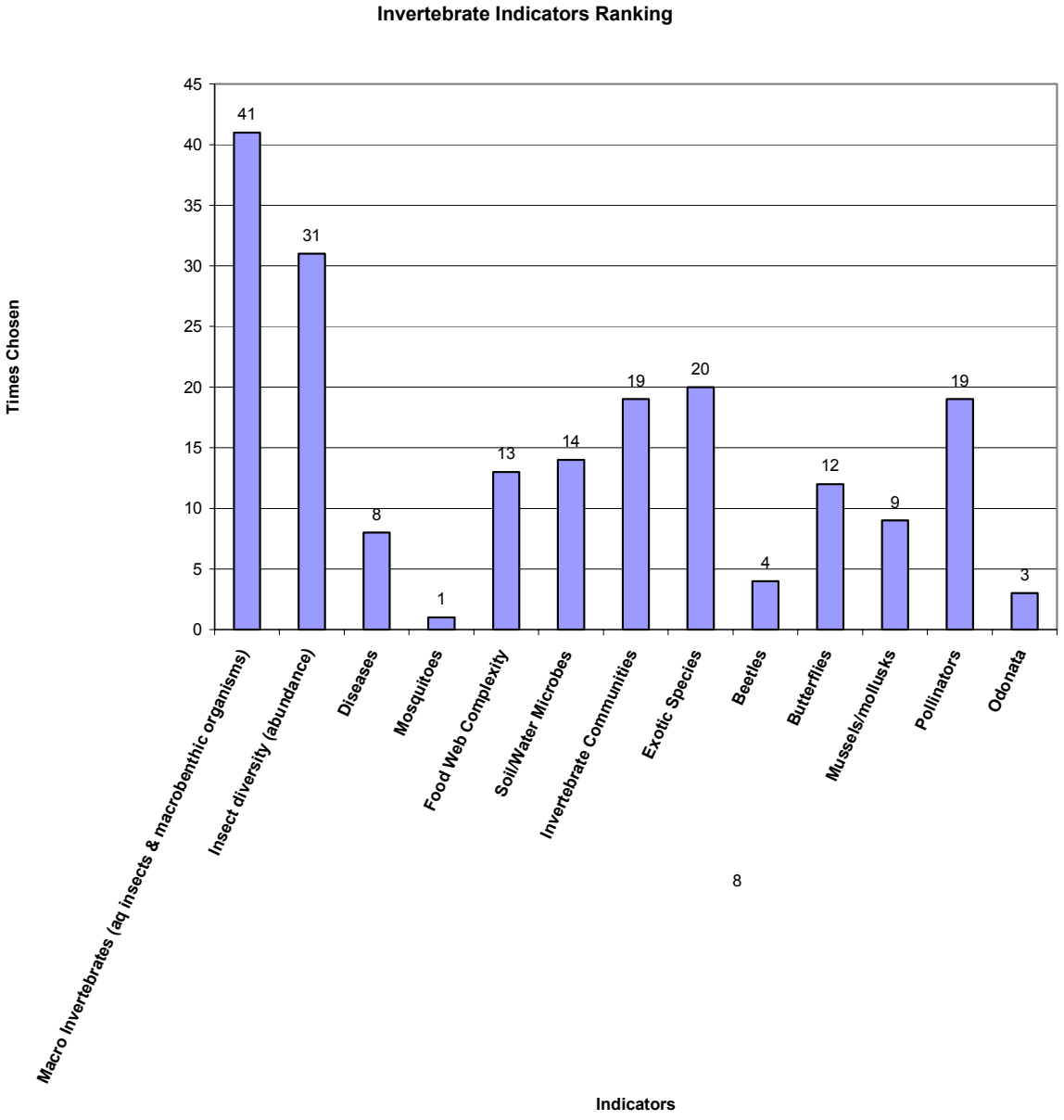
INVERTEBRATE SPECIES

Based upon your knowledge and expertise, please select the five best invertebrate species indicator topics to monitor the vital signs of these parks.

Please check no more than 5 indicator topics below by clicking to mark or unmark 5 boxes.

Choose only 5:

Number of Votes	Species	Number of Votes	Communities	Number of Votes	Other
41	Macroinvertebrates (aquatic insects & macrobenthic organisms)	31	Insect diversity (abundance)	8	Diseases
1	Mosquitoes	13	Food web complexity		
14	Soil/water microbes	19	Invertebrate communities		
20	Exotic species				
4	Beetles				
12	Butterflies				
9	Mussels/mollusks				
19	Pollinators				
3	Odonata				
31	*I do not have enough expertise to select invertebrate species indicator topics.*				


Invertebrate Indicators Ranking
Times Chosen
45
40
35
30
25
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15
10
5
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41
31
8
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13
14
19
20
4
12
9
19
3
Macro Invertebrates (aq insects & macrobenthic organisms)
Insect diversity (abundance)
Diseases
Mosquitoes
Food Web Complexity
Soil/Water Microbes
Invertebrate Communities
Exotic Species
Beetles
Butterflies
Mussels/mollusks
Pollinators
Odonata
8
Indicators

Table 1: Other Resource Components or Ecosystem Processes and Reasons for selection as an important monitoring priority

At the end of the survey, respondents were asked, "Are there any other resource components or ecosystem processes that you think should be monitored to assess the condition and trend of ecosystems in these national parks?" About 21 people responded as follows:

Other Resource Components or Ecosystem Processes					
Row Number	*Other Resource Components or Ecosystem Processes*	*Reason for selection as an important monitoring priority (including existing or potential threats):*	**YNP**	**GT**	**BH**
4	The social and economic forces affected by and/or located in proximity of the parks.	The human population in and around the parks have a direct effect upon the ecological health of the parks and their non-human inhabitants. The larger area is a part of the ecosystem within which the parks are located.			
17	Potential ecosystem responses to projected future climate changes including changes in community composition, ecosystem interactions, fire regime, and exotic invasions.		1	1	1
19	Homo sapiens	Critical impact on health of parks!			
20	snow pack over time	a measure of climate change	1	1	
23	small, headwater lake chemistry and hydrology	These systems will respond rapidly to changes in pollution and global change	1	1	
26	I would emphasize getting a better understanding of the interplay between climate variation and atmospheric N loading in the Yellowstone/Teton region. Monitoring light as a component of climate is important, but irradiance networks in the region are deficient. As such, I would like to see a network of sites within the parks which continuously monitor wind, light, temperature, precipitation. Along side this, I would like to see more intensive precipitation sampling for chemistry (more sites in NADP network)	Changes in N loading rates to the Greater Yellowstone Ecosystem will have profound effects on all terrestrial and aquatic communities, but we don't yet fully understand the complex interactions between climate and recent increases in anthropogenically derived atmospheric N. This can affect rates of Carbon fixation, nutrient sequestration and a host of other ecosystem properties, not to mention having profound changes in species composition in forests and aquatic systems.	1	1	
35	Habitat availability for seasonal movements.	Many of the species in these parks move off of park lands to seasonal ranges for part of their annual habitat needs, such as winter range. Some raptors fledged outside the park move into the park high country post	11	1	

Other Resource Components or Ecosystem Processes					
		fledging for fall hunting habitat.			
38	Chemistry of geothermal systems: chemical and isotopic	A good indicator of changes in the park plumbing systems. If changes, how this may affect flora and fauna.	1		
39	1. Spring Discharge, temperature, Cl concentration (Yellowstone)	I anticipate significant interest in geothermal energy extraction As energy issues become more critical in the next century. Without Baseline data, Yellowstone will not be ready for the attack. Other energy issues may also relate including Coal Bed Methane Development adjacent to the park particularly on the North Boundary Near Gardiner. This may be what you meant in the Physical parameters List, but this is very important.	1		
41	climate variability and ecosystem response (past and ongoing)	These systems are and always have been dynamic. All have undergone changes during the past decade, century, millennium, and beyond. All will change with ongoing global change. We don't understand the dynamics of these systems in relation to climate variability, which influences everything from woodland invasion to stand demography to fire and disease susceptibility.	1	1	1
44	The impacts of weather on all resources	Weather influences all of the resources in these areas and unless you understand these effects, you do not get the proper relationship and causes of changes that are occurring within the ecosystem.	1	1	1
48	climate variability and ecosystem response (past and ongoing)	These systems are and always have been dynamic. All have undergone changes during the past decade, century, millennium, and beyond. All will change with ongoing global change. We don't understand the dynamics of these systems in relation to climate variation	1	1	1
56	Road kills and injuries of wildlife, and other detrimental effects on wildlife and habitats	Roads are possibly the most widespread and significant, common impact on the ecosystem. Lots of effort and money is being put into building and expanding roads, needs monitoring for effective mitigation of impacts.			

Other Resource Components or Ecosystem Processes					
57	In general, identify the variables or processes that are most likely to be influenced by human activity, to the best of our current knowledge, to the point where they present an ecosystem condition that we genuinely would be concerned about.	The three parks are dynamic systems that will change through time. We shouldn't be concerned about that, unless the changes appear to be the adverse effects of human activities such as pollution, introduced species, recreational impacts, the impacts of fire supression			
66	Climatology		1		
73	Historic vegetation patterns/patterns over time. This would indicate successional changes and other events.	Climatic changes that will cause later management issues/actions.	1	1	1
75	Suite: native fishes, mollusks, crayfish	Across North America these are the creatures that have sustained the highest losses (as a percentage of the total originally there)	1	1	1
78	Insects and diseases of forested communities	Continuing loss of whitebark pine from mountain pine beetle; potential for outbreak of white pine blister rust on white bark pine. There is a wealth of data from the 60's and 70's on such forest/disease outbreaks that has not been monitored into the 80's and 90's.	1	1	
91	Hydrologic systems - both thermal and non-thermal	Hydrology was not specifically mentioned; the YELL geothermal system must be monitored, by law.	1		

Table 2. Indicator Topic Suggestions:

Physical Indicator Topics	
Row Number	*If any of the 5 items you checked above apply specifically to one park (Bighorn, Yellowstone, or Grand Teton) please tell us in the space.*
19	Yellowstone: geothermal
24	Monitoring glaciers would only apply to GRTE because it is the only park of the three that has them. It would be good for them to monitor them to help keep track of climatic change to keep track of changes that may affect biotic communities. This indicator could be used by all three units.
26	Precipitation... can control growth of forests (low growth in drought) and can control nutrient flow to aquatic systems (high terrestrial mineralization rates under heavy snow pack. Recent study has demonstrated these processes to be critical in Yellowstone Park. Acid deposition. while acidification of lakes in Yellowstone and Grand Teton park is not a great concern, the nitric acid in acid precipitation acts as a fertilizer there (where N is often limiting) causing eutrophication, and species assemblage changes. Mining effects. Yellowstone Park specifically. Measured Cooper levels in Soda Butte are high enough to impact nearly all types of aquatic biota, interactions with nutrient limitation and other stresses make the region particularly susceptible to increases in available toxic metals in aquatic and riparian systems.
29	Yellowstone National Park
31	Yellowstone
39	To my knowledge glaciers are only present in Teton. To my knowledge thermal features are largely the focus of Yellowstone. Seismic is more important in Teton and Yellowstone than Big Horn
40	Vehicular emissions and noise apply to Yellowstone.
41	Glaciers apply only to GTNP, geothermal only to YNP
47	Vehicular emissions and noise apply to Yellowstone.
54	YNP GTNP only
57	Some of the above indicators are far too vague, e.g., geologic resources, fossils, caves, mining effects, glaciers, and soil chemistry and nutrition. I hope you will be judicious in identifying indicators that can be measured in a meaningful way and with
60	Glaciers: Grand Teton Geol. Res. (volcanic, seismic): Yellowstone Geol. Res. (thermal): Yellowstone
62	Permafrost = Grand Teton Acid Deposition = Yellowstone & Grand Teton
66	Yellowstone
68	Monitoring thermal activity would apply only to Yellowstone. Glacier monitoring would only apply to Grand Teton.
73	Volcanic/seismic would apply more to Yellowstone.

Physical Indicator Topics	
75	Geothermal resources is obviously key to Yellowstone (and may be Grand Teton) but not likely to Bighorn.
76	Weather history for all 3 parks. Cryptogamic crusts at Bighorn Canyon NRA.
89	Bighorn Canyon
91	Geological Resources, Thermal - Yellowstone Mining effects - Big Horn Canyon; Yellowstone (external)
93	Historical mining in the Cooke City, Montana area has the potential for ongoing negative impacts to several streams in the northeastern portions of Yellowstone Park.

Aquatic Indicator Topics	
Row Number	*If any of the 5 items you checked above apply specifically to one park (Bighorn, Yellowstone, or Grand Teton) please tell us in the space.*
26	Eutrophication: In the Tetons and in Yellowstone, most lakes are Nitrogen (N) limited, and recent increases in atmospheric N loading are altering the productivity of aquatic systems there. This has implications for species composition and trophic dynamics as well.... Important long term trends in the effects of eutrophication can be measured through the use of studies which compare lake sediment records to current in-lake conditions. The lakes are acting as repositories for the fossils and elements which originally made up the biota of the park. The sediment record can record changes in nutrient flows through the watersheds of the region, and give us a better idea of how diffuse anthropogenic disturbance can affect ecosystems. Nutrient transport: (Along the same lines) atmospheric N loading affects aquatic systems through a complex series of interactions. N is deposited onto the landscape, and the rates at which it makes its way to the aquatic system is dependant on climate, hydrology, vegetation etc.. These processes are critical in Yellowstone and Grand Teton Park (I'm not as familiar with the ecology of Bighorn Canyon) Water Quality: Again in terms of Yellowstone and Grand Teton Parks... because the waters of this region are generally dilute in terms of nutrients, DOC and other solutes, the impact of mining activity and other toxic loads on the systems are likely to be severe when they occur. As such, it is important to track nutrients and potential toxicants together, as they are likely to have strong interactions in dilute (low DOC) environments. Aquatic community composition. Not only do organisms act as good indicators of general condition, but they respond quantitatively to impacts like changes in resource levels and nutrient supply rates along predictable sequences of species succession. Also, species diversity, can be a function of diverse habitat, disturbance, number of limiting resources and levels of productivity. It would be highly valuable were we to understand (we don't now) the relative influence of all of these ecological phenomena on species diversity in aquatic communities. High number of lakes in Yellowstone and G. Teton Park makes it an ideal place to begin to understand these interactions.

Aquatic Indicator Topics	
39	Bacterial mats (thermal) are largely focused on Yellowstone. (I do not percieve as bad the idea that some things are monitored in one place and not in another.)
41	The three I checked under the "general" category are most relevant to the natural lakes and high-order drainages in GTNP & YNP
43	Grand Teton and Yellowstone
48	The three I checked under the "general" category are most relevant to the natural lakes and high-order drainages in GTNP & YNP
50	Grand Teton and Yellowstone
54	YNP GTNP only
57	Monitoring stream flow would be less to determine the state of the ecosystem than to document long-term trends and the effects of disturbances, such as fire.
73	All would apply to all parks.
75	Apply to all
76	Water quality for all 3 parks. Direct human inputs for Bighorn Canyon NRA.
89	Bighorn Canyon

Vegetative Indicator Topics	
Row Number	*If any of the 5 items you checked above apply specifically to one park (Bighorn, Yellowstone, or Grand Teton) please tell us in the space.*
2	Your goal of selecting indicators that should be monitored at all the parks is completely off the mark. Certainly a few indicators such as those identified above should be monitored in all areas, but each park will have specific problems and challenges
3	I selected the 2 of the specific exotic species listed, but if given the choice I would have preferred to select just a general category of exotic plant species.
22	The 4 categories I chose would be appropriate for both YNP and BCNRA. A fifth category, invasive exotics, was not on the list, but should be. Fragmentation (which I marked) is an issue only as a means of describing deviations from the fragmentation pattern normal to each park. For YNP, "community structure" monitoring would include measuring status of aspen, willow, sagebrush, whitebark, and alpine communities. Community structure monitoring in BCNRA should probably focus on the mountain mahogany, shrub, and native grass communities.
26	Vegetation chemistry... Allows us to understand the limiting factors for growth (C:N:P:K), and also, if toxic metals are being incorporated into tissue in potentially inhibitory levels. As N loading is affecting ecological processes in the Yellowstone region, I would say it is critical there. Soil plant relationships... Complements the interactive study of nutrient cycling and flow through entire drainage basins, and potentially entire Yellowstone ecosystem.

Vegetative Indicator Topics	
	Location of treeline... important in understanding impacts of changing climate on terrestrial and aquatic systems in Yellowstone Park Alpine communities... highly sensitive to small perturbations, prevalent in Grand Teton park, and also Yellowstone.
30	It appears EXOTIC and NOXIOUS PLANT SPECIES was left off the above list - it should be included, as it is in the explanation for nomination, and is one of my choices for all three parks.
48	juniper woodlands mainly in BHCNRA
57	This list, like the others, presents some puzzling and sometimes difficult choices. For example, it makes sense to monitor proportion of landscape in different vegetation types, but that probably will change very slowly, perhaps too slowly to justify the
62	Whitebark Pine etc. = Yellowstone. Alpine Communities = Yellowstone & Grand Teton
66	Yellowstone
73	All would apply to all the parks.
75	Applies to all
76	Exotics for all 3 parks. Community analysis, trends, and condition should be done by all 3 parks, but the vegetation type chosen will vary on what they consider to be their dominant and most sensitive. I could see whitebark pine/limber pine/lodgepole for YELL. Sagebrush and native grasses and forbs for GRTE. Juniper woodlands and cushion plants for BICA.

Vertebrate Species Indicator Topics	
Row Number	*If any of the 5 items you checked above apply specifically to one park (Bighorn, Yellowstone, or Grand Teton) please tell us in the space.*
5	I chose my five based on the above-stated goal: application to all park units.
8	For Yellowstone and Grand Teton, clearly elk are primary ungulates that have major ramifications for a host of other species including vegetation. For Bighorn Canyon clearly bighorn sheep are the primary species of interest to the public and are sensitive.
21	I am familiar with GTNP, and believe that sage-grouse are a good indicator species for sagebrush dominated portions of the park (southern portions). Sage-grouse are being used as an indicator or keystone species throughout the west.
22	I selected bears, elk, and bison for YNP. These species are minor players (if present) in Bighorn Canyon. Bighorn Canyon monitoring should include the top herbivores - horses, sheep, mule deer, - just as in YNP. BCNRA does not have an equivalent "problem" carnivore like bears in YNP. Other taxa (birds, herps, small mammals, small carnivores, etc.) should be monitored in both parks but on an extensive species presence basis.
29	Yellowstone National Park Grand Teton National Park
54	YNP GTNP only
66	Yellowstone
73	All would apply to all the parks. These would include the other topics.
75	Applies to all
76	I think the less studied ungulates and forest carnivores may tell us more about conditions, but it might be useful to define one (or more) keystone species for each ecosystem.

Invertebrate Species Indicator Topics	
Row Number	*If any of the 5 items you checked above apply specifically to one park (Bighorn, Yellowstone, or Grand Teton) please tell us in the space.*
5	I include Odonata and Mosquitoes under macroinvertebrates (aquatic insects)
29	Yellowstone National Park Grand Teton National Park
57	Naturally, the diversity of any group would be good to measure, but that seems like a difficulty indicator to monitor, and one that might be difficult to interpret too. I would emphasize the rare and endangered species. If we monitor them, and try to ma
75	Applies to all parks
76	Macroinvertebrates can tell a very large ecosystem health story for all 3 parks. Secondary to that, I believe pollinators can bring in even a larger landscape scale condition.

Table 3. Other suggestions concerning vital signs monitoring in Bighorn Canyon, Grand Teton, or Yellowstone National Parks:

Other Suggestions	
Row Number	*Other suggestions concerning vital signs monitoring in Bighorn Canyon, Grand Teton, or Yellowstone National Parks:*
6	Amphibian monitoring is a high DOI priority (the Amphibian Research and Monitoring Initiative). The GYE is an important component of a North to South transect of Rocky Mountain parks (including Glacier and Rocky Mtountain) that has been identified as important for
28	It's important to recognize that physical disturbance processes such as landslides are relatively common natural events in many parts of Yellowstone and Grand Teton and are not necessarily direct indicators of ecosystem degradation. Also, we are far from understanding what physical characteristics of streams such as channel morphology "should be" in terms of sustaining ecosystem function, and a major goal of any stream monitoring should be to understand more about these systems rather than to immediately draw conclusions about the state of, or trends in, the health of stream systems.
33	Nutrients in lakes leading to eutrophication in the Tetons and Yellowstone.
34	The current monitoring of base line organisms in hot springs should be expanded to eventually include a majority of springs within the park.
38	Geology affects nearly everything. Thus the chemistry of surface materials--rock, soil, stream sediment, geothermal waters and deposits, surface and ground water, and air, as well as flora and fauna, are critical to any monitoring.
44	Most monitoring need to be for long periods and needs to be consistent. So much of present monitoring is short-term and can present a false of inconclusive conclusion. Monitoring needs to be funded consistently and not subject to budgetary cycles.
45	Historically, many of the indicators used in these parks have been single species and vertebrates. Better data (higher abundances, more diversity of species and thus more rigorous statistical analyses) can be obtained from the perspective of indicators using some of the invertebrate fauna and the plant community. It would be advantageous to try to balance out the charismatic mega-fauna approach with a broader community perspective.
51	Most monitoring need to be for long periods and needs to be consistent. So much of present monitoring is short-term and can present a false of inconclusive conclusion. Monitoring needs to be funded consistently and not subject to budgetary cycles.
52	Historically, many of the indicators used in these parks have been single species and vertebrates. Better data (higher abundances, more diversity of species and thus more rigorous statistical analyses) can be obtained from the perspective of indicators
57	See my previous comments. I'm concerned at the moment that the lists do not present good choices of indicators that, realistically, will or can be monitored over a long period of time. Considerable refinement seems necessary. No doubt that is what you
73	You noted "noise" but it wasn't clear where this fit. I think noise is a very critical element. Particularly overflights.
80	For "vital signs", might want to focus on those parameters that will have utility and be indicative of ecosystem functions over the long haul. Discreet, more specific lines of inquiry (such as inventories or elucidating specific relationships) might be more appropriate to pursue as finite studies that compliment the vital signs monitoring, rather than as the vital signs themselves.

Other Suggestions	
93	Most of the selections listed above are elements that could be monitored in any of the parks. Concerns about specific aquatic nuisance species and diseases may currently be restricted to a single park where they occur but these conditions should be monitored