National Park Service

Presentation on the Proposed Restoration of Native Species in High Elevation Aquatic Ecosystems

Sequoia and Kings Canyon National Parks

May 21, 2010

The Purpose of the National Park Service

"…to conserve the scenery, the natural and historic objects, and wild life therein, and to provide for the enjoyment of those resources in such a manner as to leave them unimpaired for future generations."

Organic Act 1916

Photo by Nancy Hendricks, 2009

The National Park Service Mandate

The NPS will strive to restore native species to parks when

- Adequate habitat is available.
- The species was diminished or reduced due to indirect or direct human influence.
- Potential impacts have been carefully considered.

Photo by Bryan Czibesz, 2004

Management Policies 2006

The National Park Service Mandate

Exotic species will be managed when…

- They interfere with natural processes, natural habitats or native species, or
- They disrupt the genetic integrity of native species.

Management Policies 2006

Photo by Danny Boiano, 2002

Sequoia and Kings Canyon National Parks

Our Mission

- **To protect forever the greater Sierran ecosystem including the sequoia groves and high Sierra regions of the parks and its natural evolution.**

- **To provide appropriate opportunities to present and future generations to experience and understand park resources and values.**

Photo from Wikipedia Commons

Purpose of the Proposed Plan/EIS

- To guide mgt. actions by the NPS to restore and conserve native species diversity and ecological function to selected high elevation aquatic ecosystems.

- Plan would be implemented over 25-30 years, with re-evaluation every 5-10 years.

Photo by Bryan Czibesz, 2004

Need for the Proposed Plan/EIS

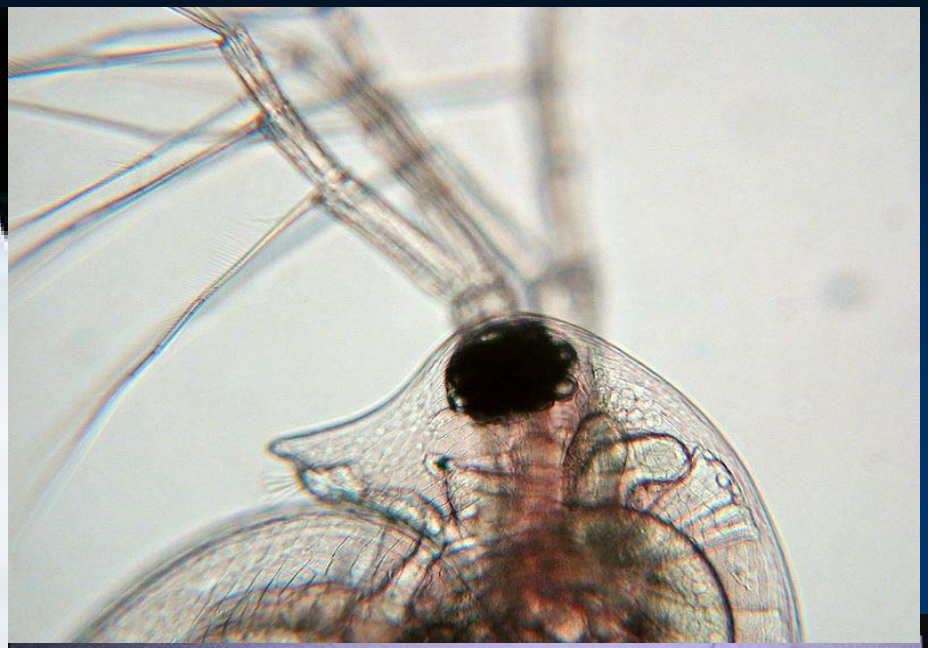
- This plan/EIS is needed because the natural abundances and distributions of native species are being adversely impacted, primarily by the presence of introduced non-native species, resulting in losses of biological diversity and ecological function in high elevation aquatic systems.

Photos by Dr. Roland Knapp, Danny Boiano, and from CalPhotos

High Elevation Aquatic Ecosystem (native species follow)

Photo by Erik Meyer, 2009

Cladoceran Zooplankton (predator and prey)



Photos from Wikipedia Commons

Copepod Zooplankton (predator and prey)

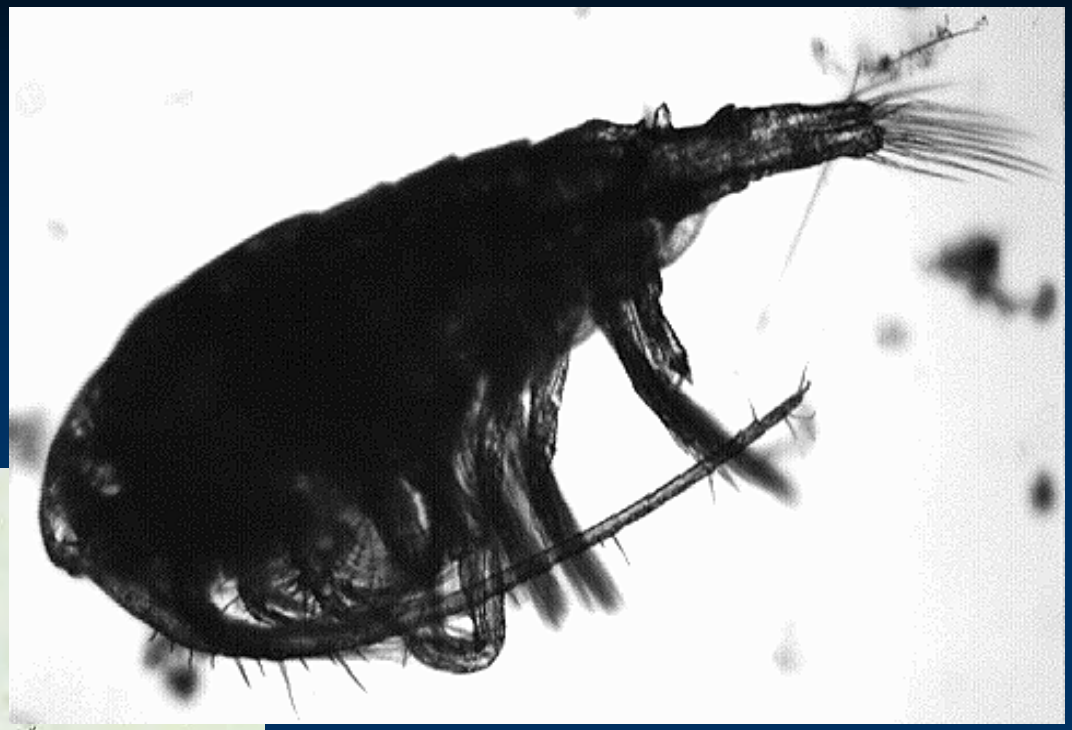


Image provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

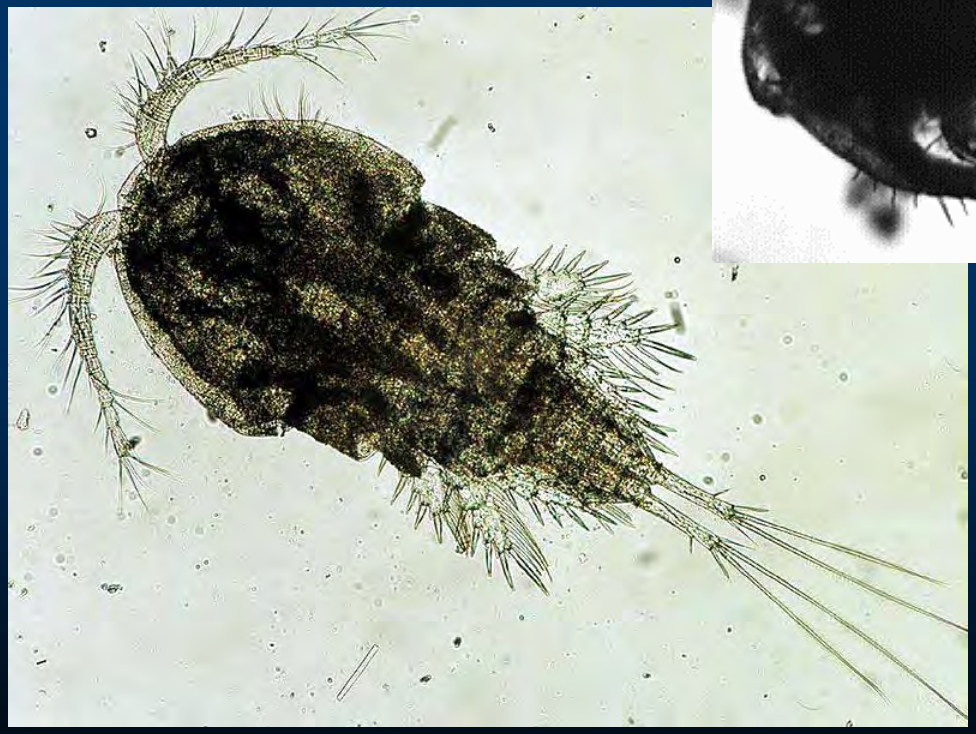


Photo from Wikipedia Commons

Mayfly (predator and prey)

Photo from Wikipedia Commons

Caddisfly (predator and prey)

Photos from Wikipedia Commons

Predaceous Diving Beetle (predator and prey)

Photos from Wikipedia Commons

Dragonfly (predator and prey)

Photos from Wikipedia Commons

Pacific Treefrog (predator and prey)

Photo by Kevin Skeen, 2007

Mountain Yellow-Legged Frogs (MYLF; predator and prey)

Photo by Erik Meyer, 2009

High Elevation Lake (typical MYLF habitat)

Photo by Danny Boiano, 2003

Mountain Garter Snake (predator)

Photos by Erik Meyer, 2009 and Kevin Skeen, 2007

Brewer's Blackbird (predator)

Photo from Wikipedia Commons

Clark's Nutcracker (predators) Gray-crowned Rosy Finch

Photos from Wikipedia Commons

Long-tailed Weasel (predator)

Photo from Wikipedia Commons

Yosemite Toad (predator and prey)

Photos by Jennifer Rains Jones, 2009 and Joyce Gross, 2001 (from CalPhotos)

Arctic Willow

Photo by Danny Boiano, 2003

High Elevation Basin (upper slopes often have permanent snow)

Photo by Danny Boiano, 2003

Mount Lyell Salamander (predator and prey)

Photo by Dr. Vance Vredenburg, 2000 (from CalPhotos)

High Elevation Aquatic Ecosystems (SEKI protects a lot)

Photo by Danny Boiano, 2003

FOCUS - Mountain Yellow-legged Frogs (*Rana muscosa, Rana sierrae*)

- Endemic to high elevation waters in SN and So. CA
- Were one of most abundant vertebrates in high Sierra
- Predator, prey and critical agent of nutrient cycling
- Very important species to these ecosystems

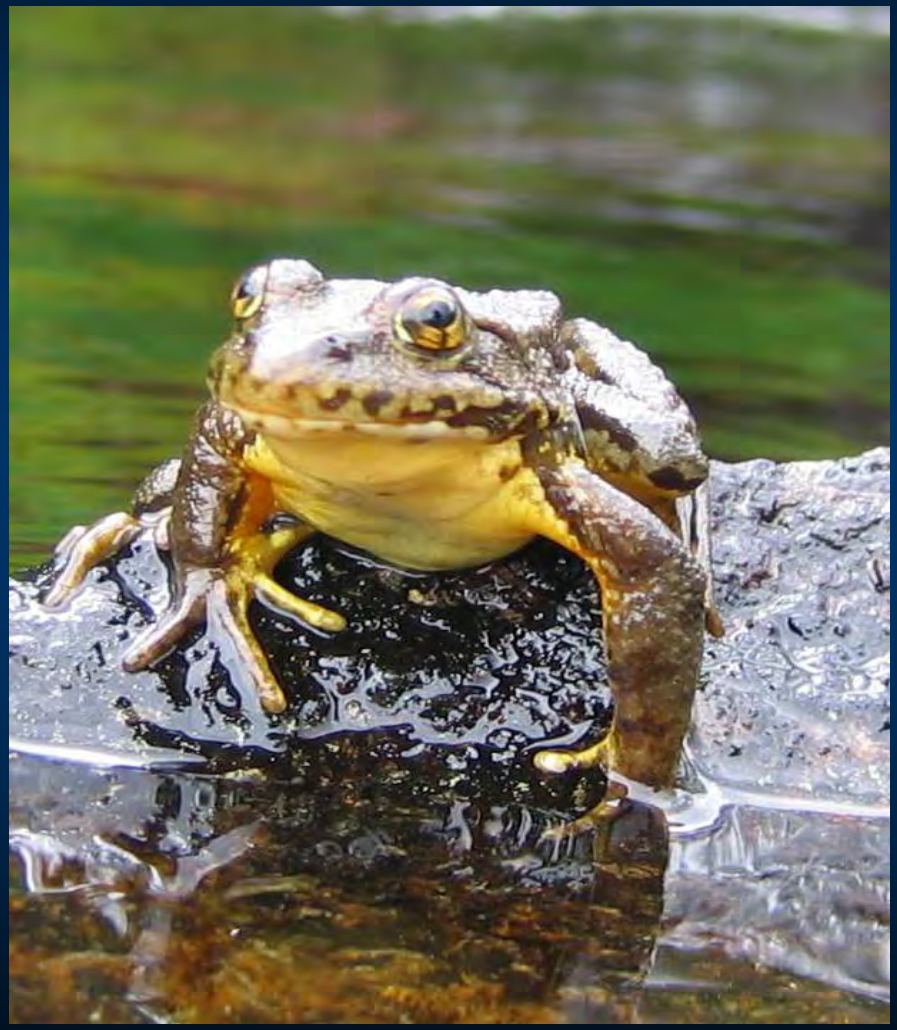


Photo by Bryan Czibesz, 2004

Mountain Yellow-Legged Frogs - Egg Masses

Photo by Dr. Vance Vredenburg, 2000 (from CalPhotos)

Mountain Yellow-Legged Frogs - Tadpoles

Photos by Danny Boiano 1997, 2002 and Harold Werner, 2006

Mountain Yellow-legged Frogs - Adults

Photos by Bryan Czibesz, 2004 and Danny Boiano, 2002

Mountain Yellow-legged Frogs in Severe Decline

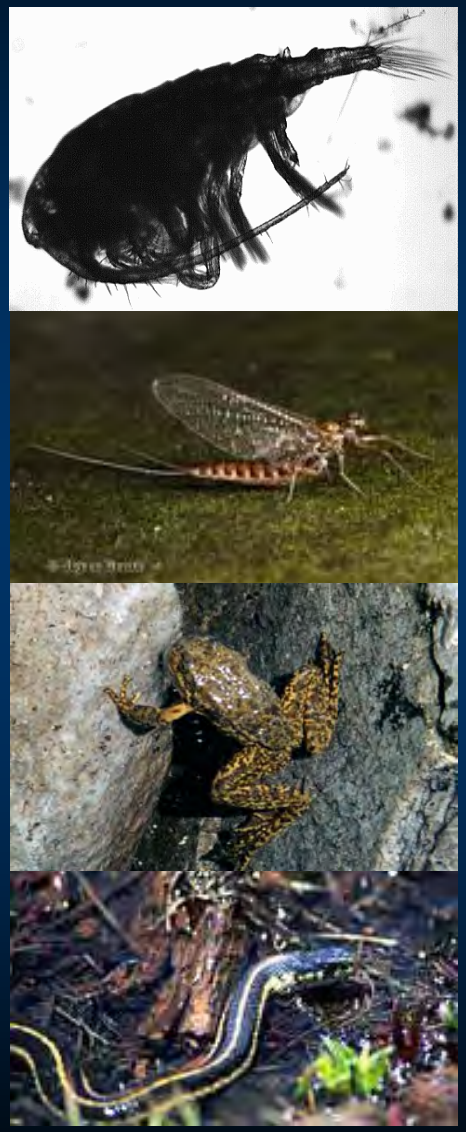
- Disappeared from 92% of historic localities in SN
- 2003 & 2007 - given "warranted but precluded" listings under the federal Endangered Species Act

Photo by Dr. Vance Vredenburg, 1998 (from CalPhotos)

- May soon be listed as threatened or endangered

Sequoia and Kings Canyon National Parks

- More than 3,000 lakes, ponds and wet meadows (~1000 lakes, ~2000 ponds...)
- All at high elevation and naturally fishless due to cascade barriers left by glaciers (some native species shown to right)
- 1860s-1988: non-native trout were introduced to majority of lakes (packstock, airplane)



Photos by Dr. Roland Knapp, Danny Boiano, and from CalPhotos

Fish Stocking (species follow)

Photo from www.mylfrog.com

Photo from Johnston, H. 1995. Yosemite trout

Photo from www.mylfrog.com

Rainbow Trout

Photo by Danny Boiano, 1996

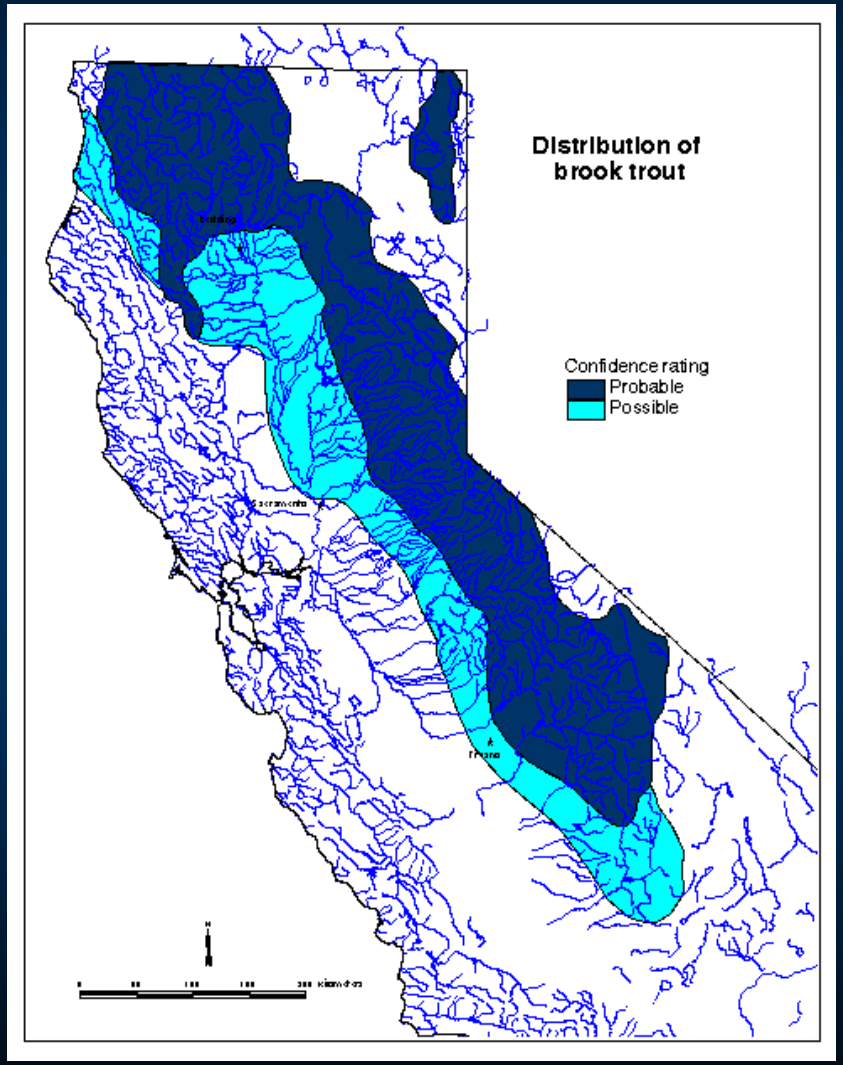
Golden x Rainbow Trout Hybrids

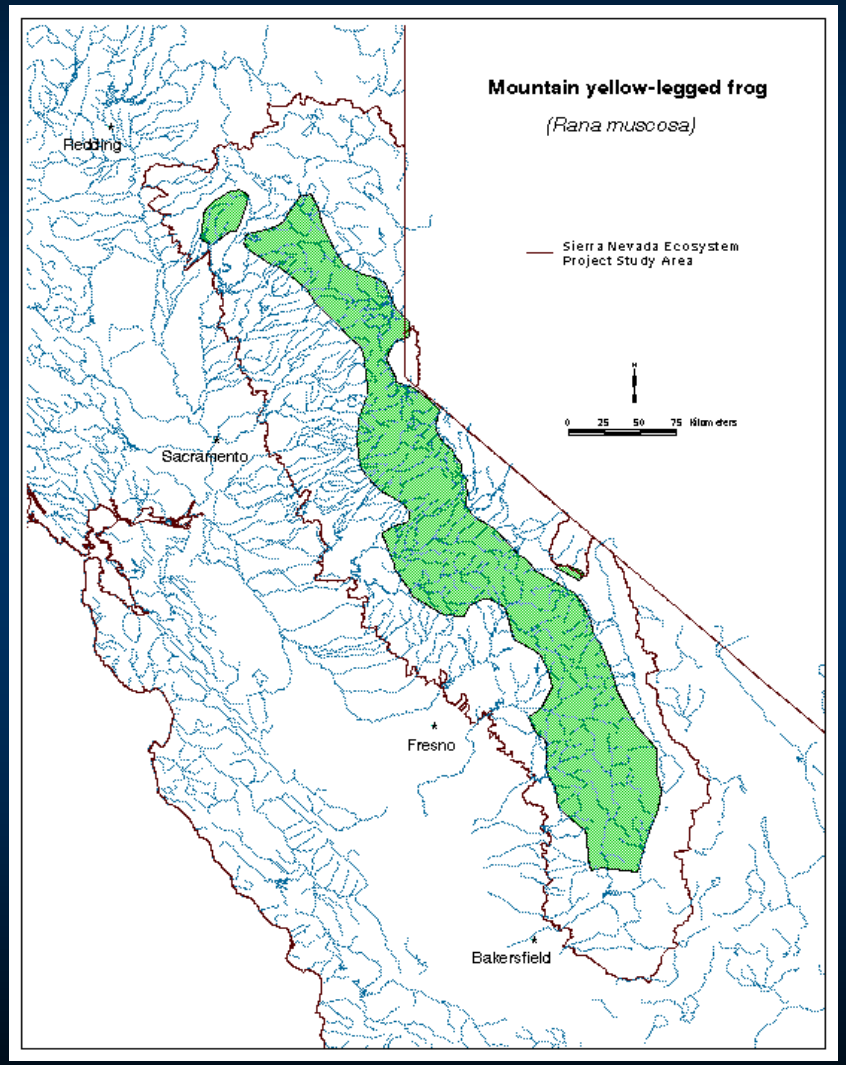
Photo by Danny Boiano, 2002

Eastern Brook Trout

Photo by Danny Boiano, 1996

Distributions of Non-native Trout and Mountain Yellow-legged Frogs (MYLF)





Maps from University of California Davis, Information Center for the Environment

Sierra Nevada (Today)

- Trout introductions in national parks stopped in 1988-1990, but continue in national forests

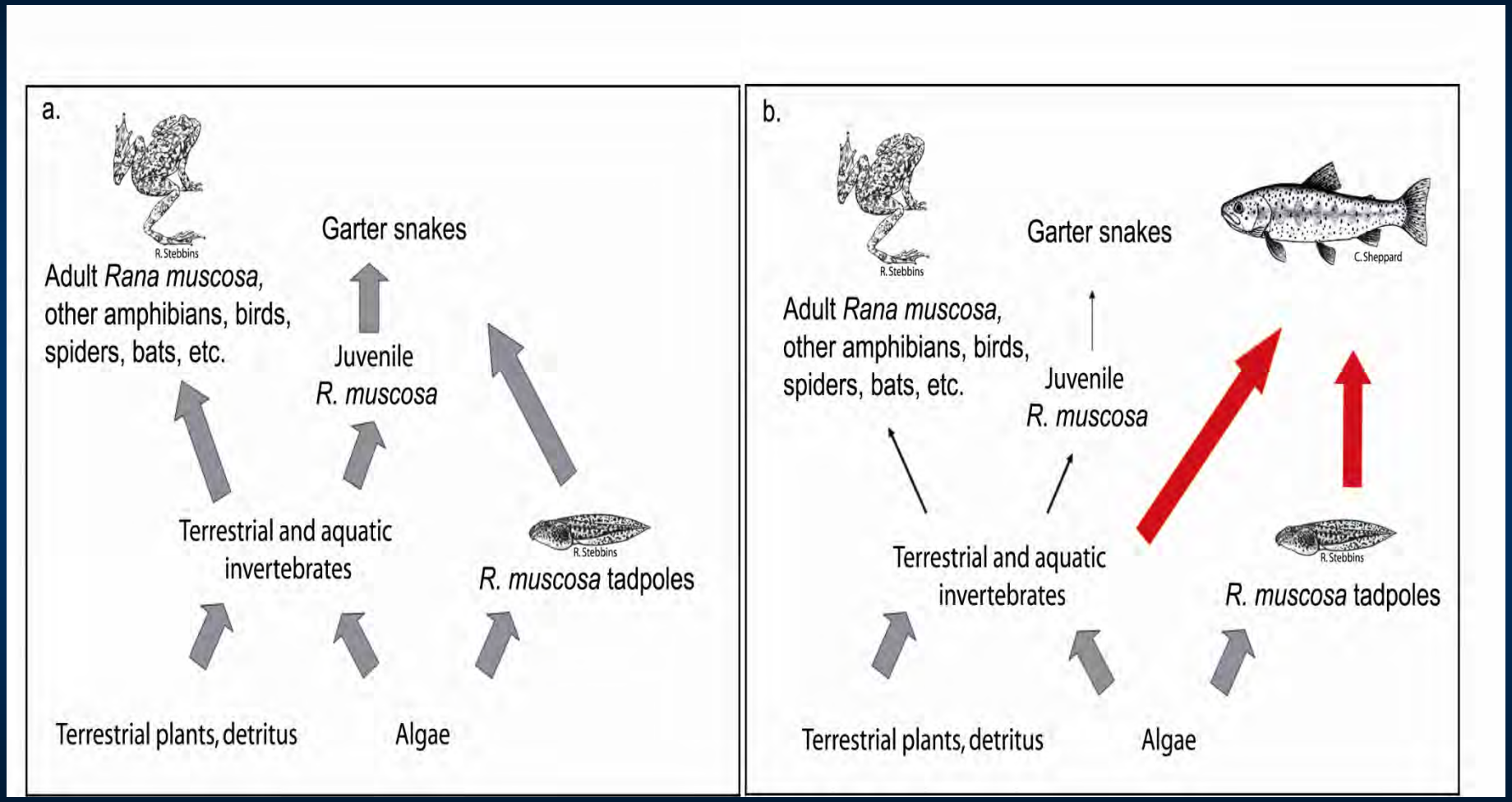
- Majority of large lakes now contain trout:
  ~90% of large lakes in NFs
  ~50% of large lakes in NPs

Data from Knapp 1996. Sierra Nevada Ecosystem Project.

Photo by Danny Boiano, 2003

- Many studies have determined that trout negatively impact native animals, and food webs / ecosystems

Introduced Trout Change the Food Webs



Data from Finlay and Vredenburg. 2007. Ecology 88:2187-2198

Non-native Trout versus Other Threats

Non-native trout are a proven *major* factor in MYLF decline

Other Threats:

- Disease
- Contaminants
- Climate change

Largely out of park control

Managing trout populations is mostly within park control

Photo by Danny Boiano, 1996

Ongoing Restoration Project

- 2001 - NPS Regional Director approved trout removal by gill netting and electrofishing

- 2001 - Initiated 6 lakes
  2004-05 - Initiated 5 lakes
  2009 - Initiated 6 lakes

- Ongoing
  - Reclaiming habitat for existing frog populations
  - Testing feasibility and thresholds
  - Surveys to measure frog density in restoration and control habitats

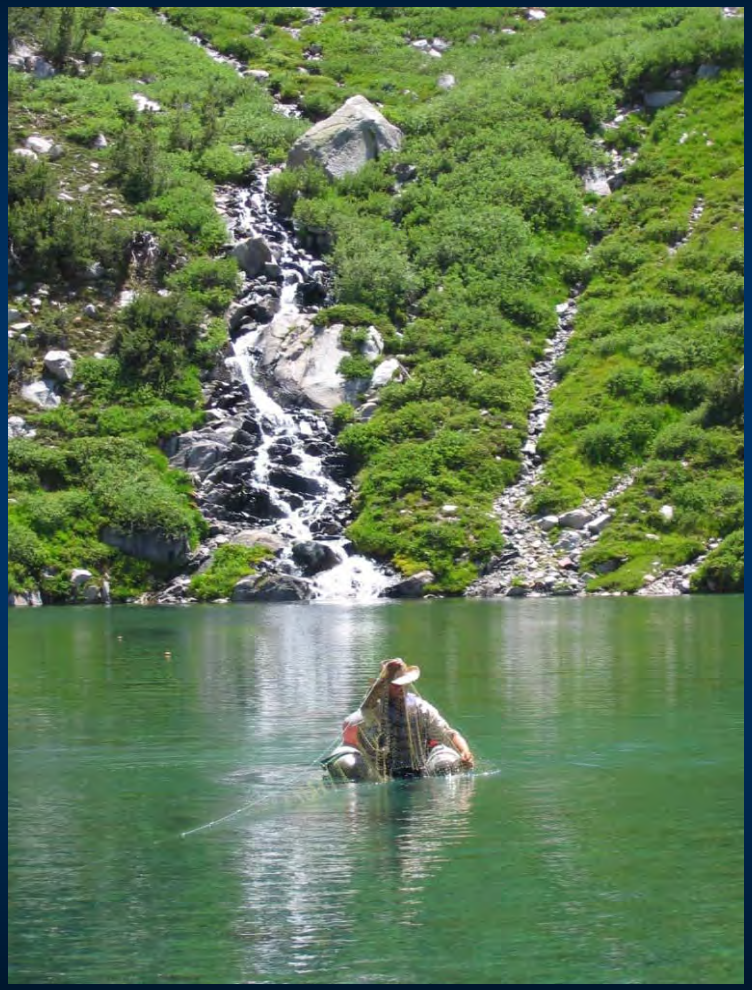


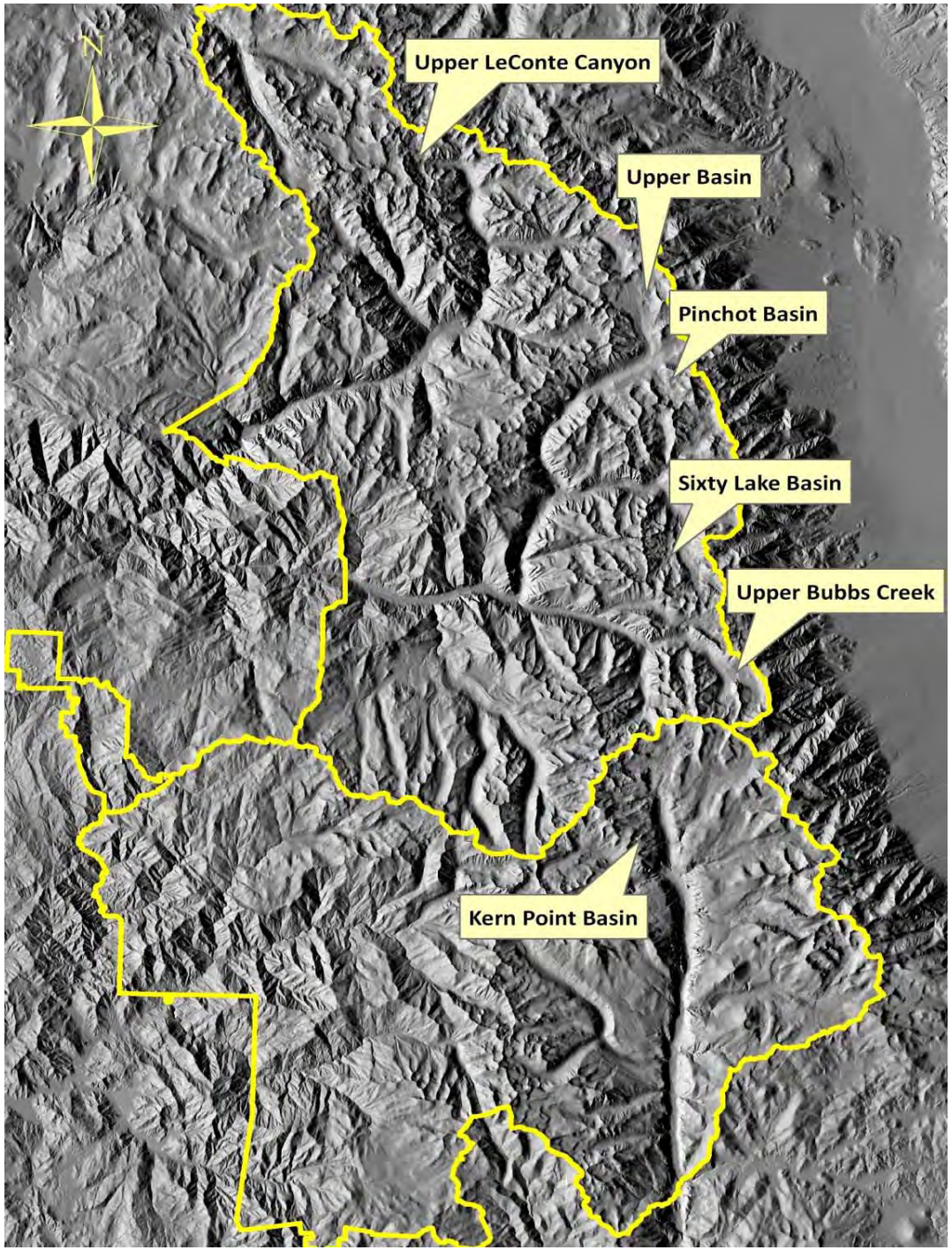
Photo by Bryan Czibesz, 2004

Selection Criteria: Headwater Habitats

Photo by Danny Boiano, 2002

Selection Criteria: Good MYLF Breeding Sites

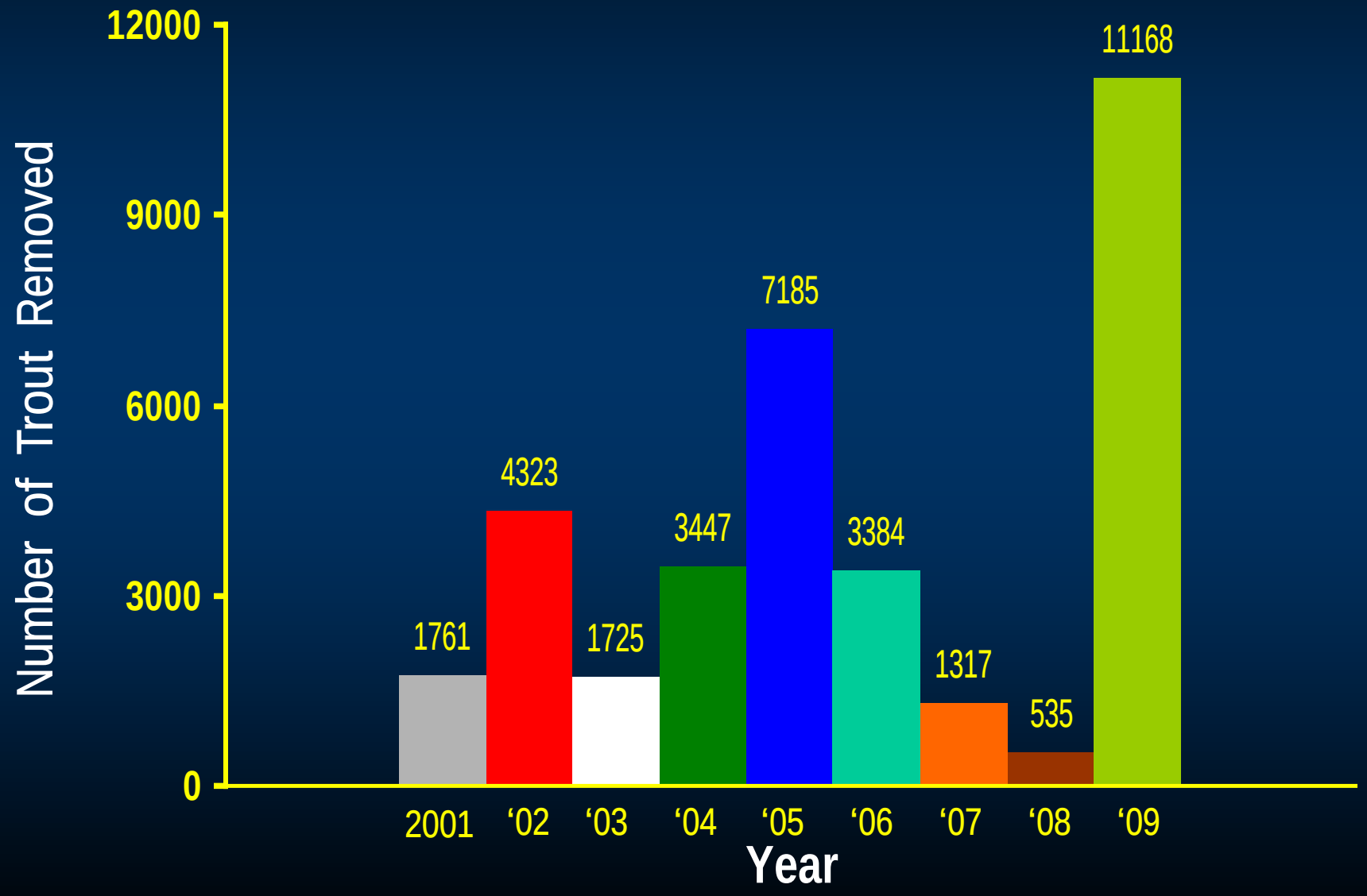
Photo by Danny Boiano, 1997



SEKI Restoration Sites

Ongoing Restoration: 2001-2009

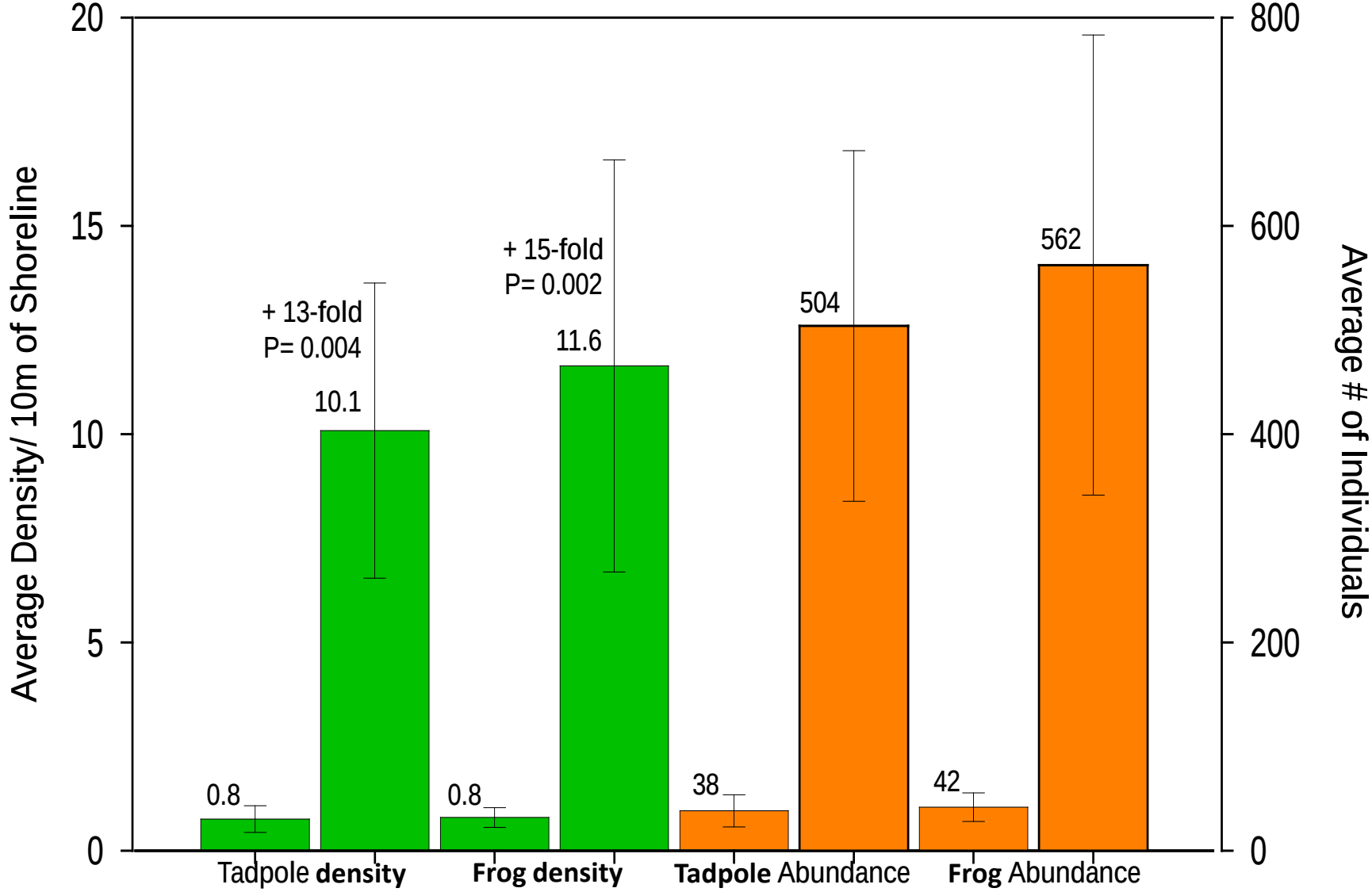
34,845 non-native trout removed from 17 lakes/streams



MYLF Response to Fish Removal

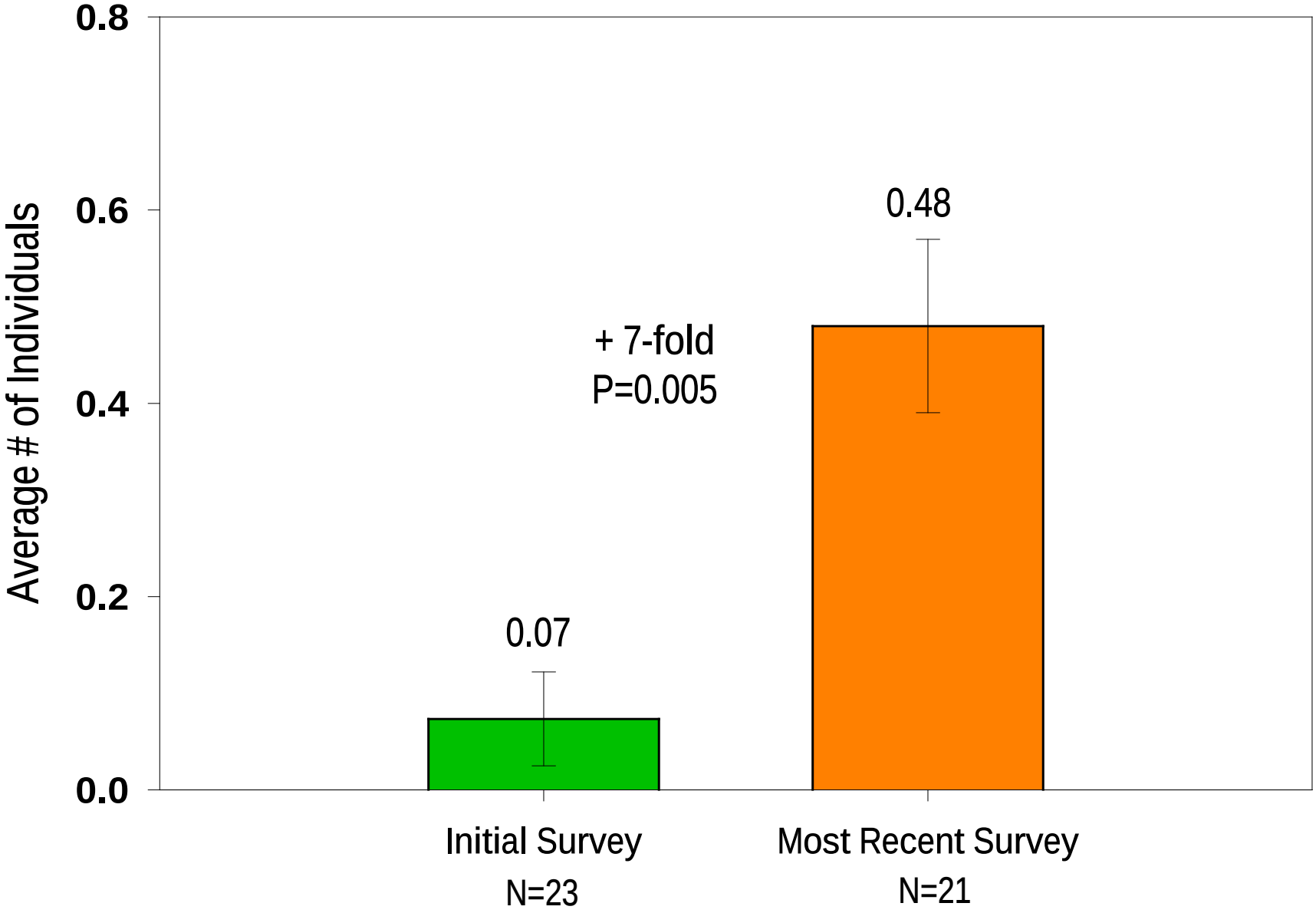
- 11 lakes with at least 95% of fish removed (functionally eradicated)
- Varying times since reaching 95% fish removal
- Reporting MYLF response measured in 3rd year past 95% fish removal allows:
  - standard comparison between all sites
  - enough time for MYLF biology to respond
- MYLFs in 2 lakes became diseased before reaching 95% fish removal
- MYLFs in 9 lakes remained disease-free 3 yrs past 95% fish removal
  (These 9 lakes used for following 2 graphs.)

Average Mountain Yellow Legged Frog Response in Nine Restoration Lakes Three Years Post Removal of 95% of Fish in Each Lake



Average density (number counted per 10 meters of shoreline per survey) and average abundance (number counted per survey) of mountain yellow-legged tadpoles and frogs in nine restoration lakes in SEKI that remained disease-free three years after removal of 95% of fish in each lake. Baseline averages (left bar of each pair) were calculated from frog surveys conducted in the initial year of restoration in each lake, and response averages (right bar of each pair) were calculated from frog surveys conducted three years past the year in which 95% of fish were removed from each lake. One to three surveys were conducted per lake during each season.

Mountain Garter Snake (*Thamnophis elegans elegans*) Increased in Nine Lakes After Fish Removal



LeConte Restoration Site

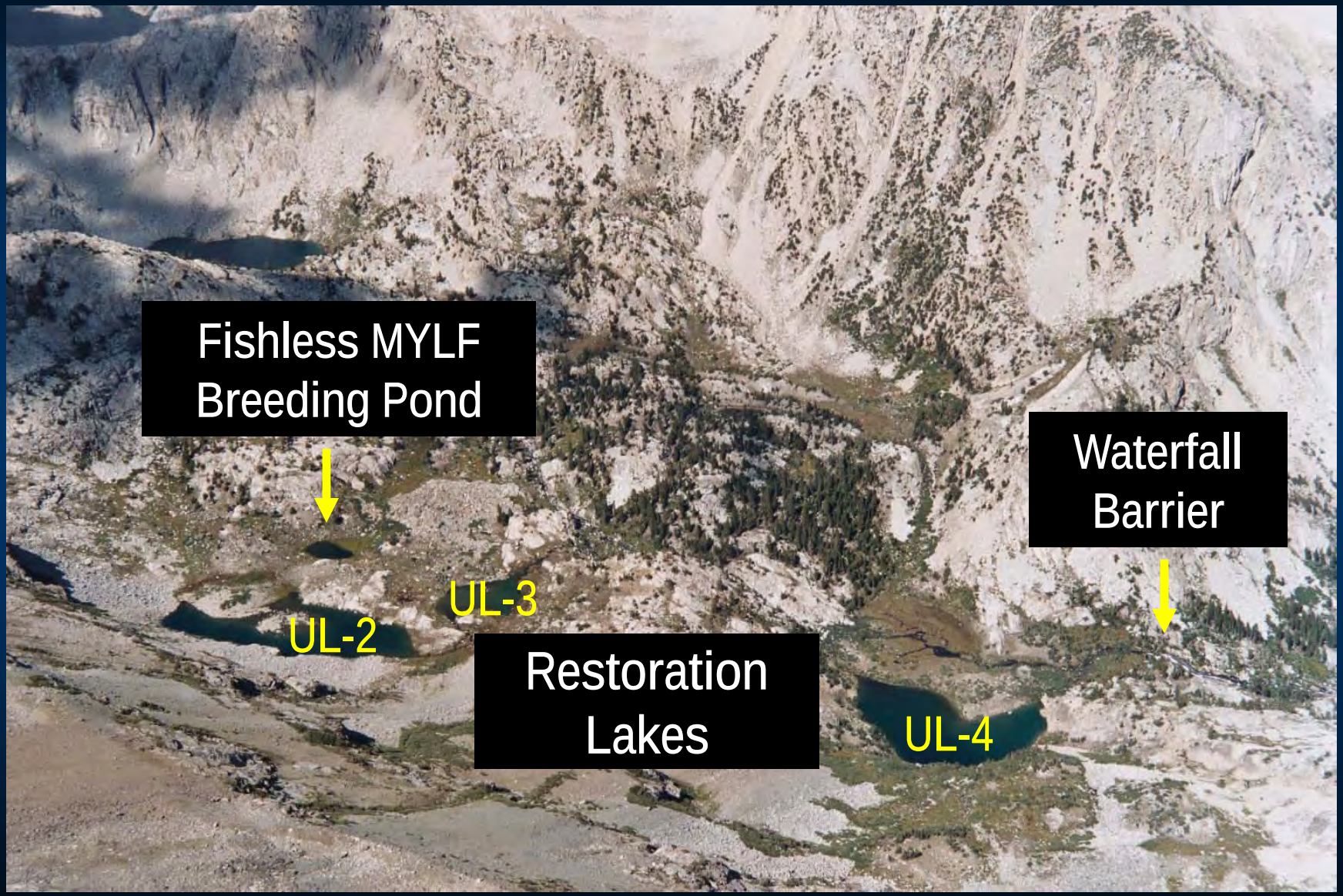
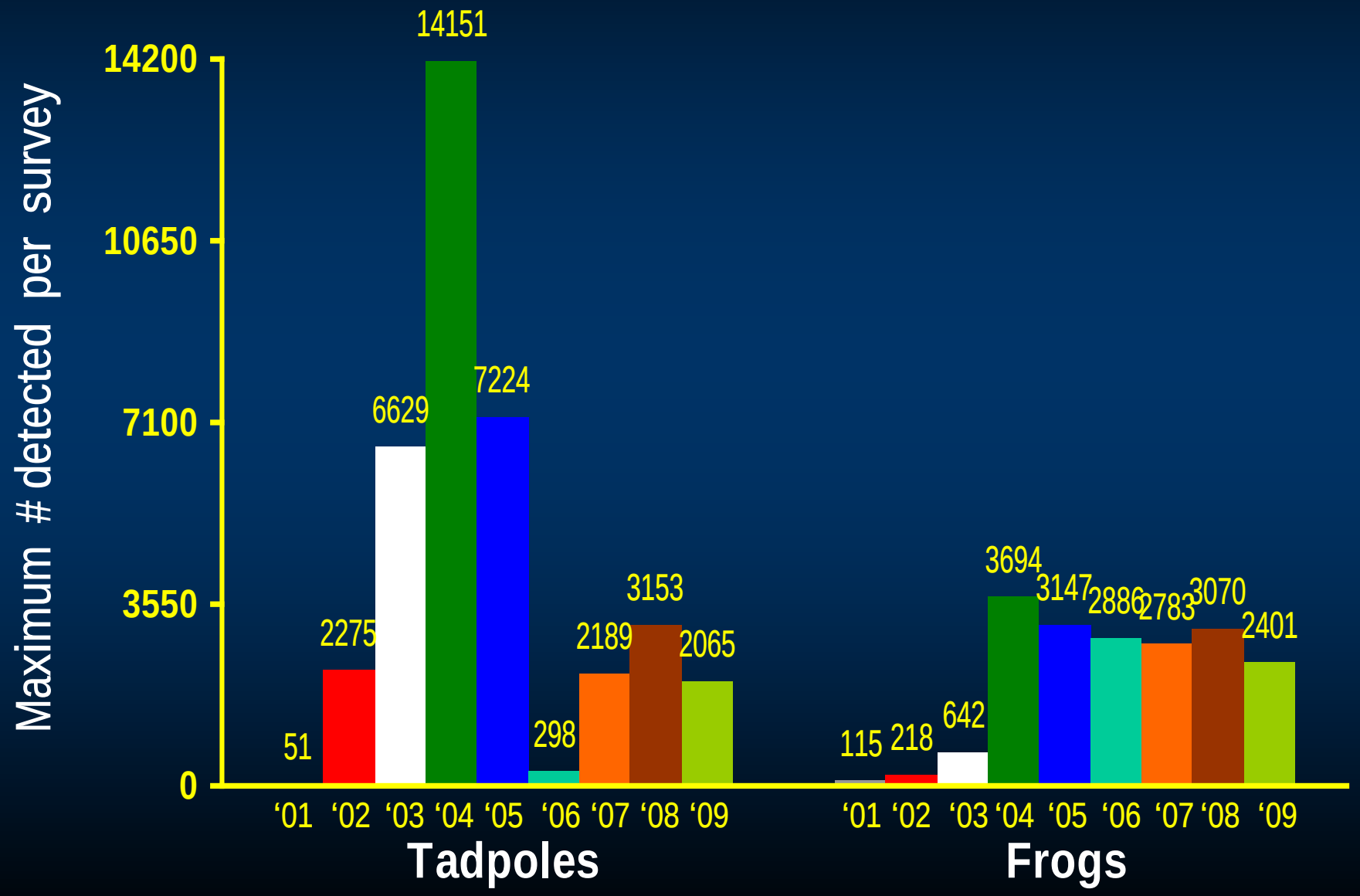


Photo by Danny Boiano, 2003.

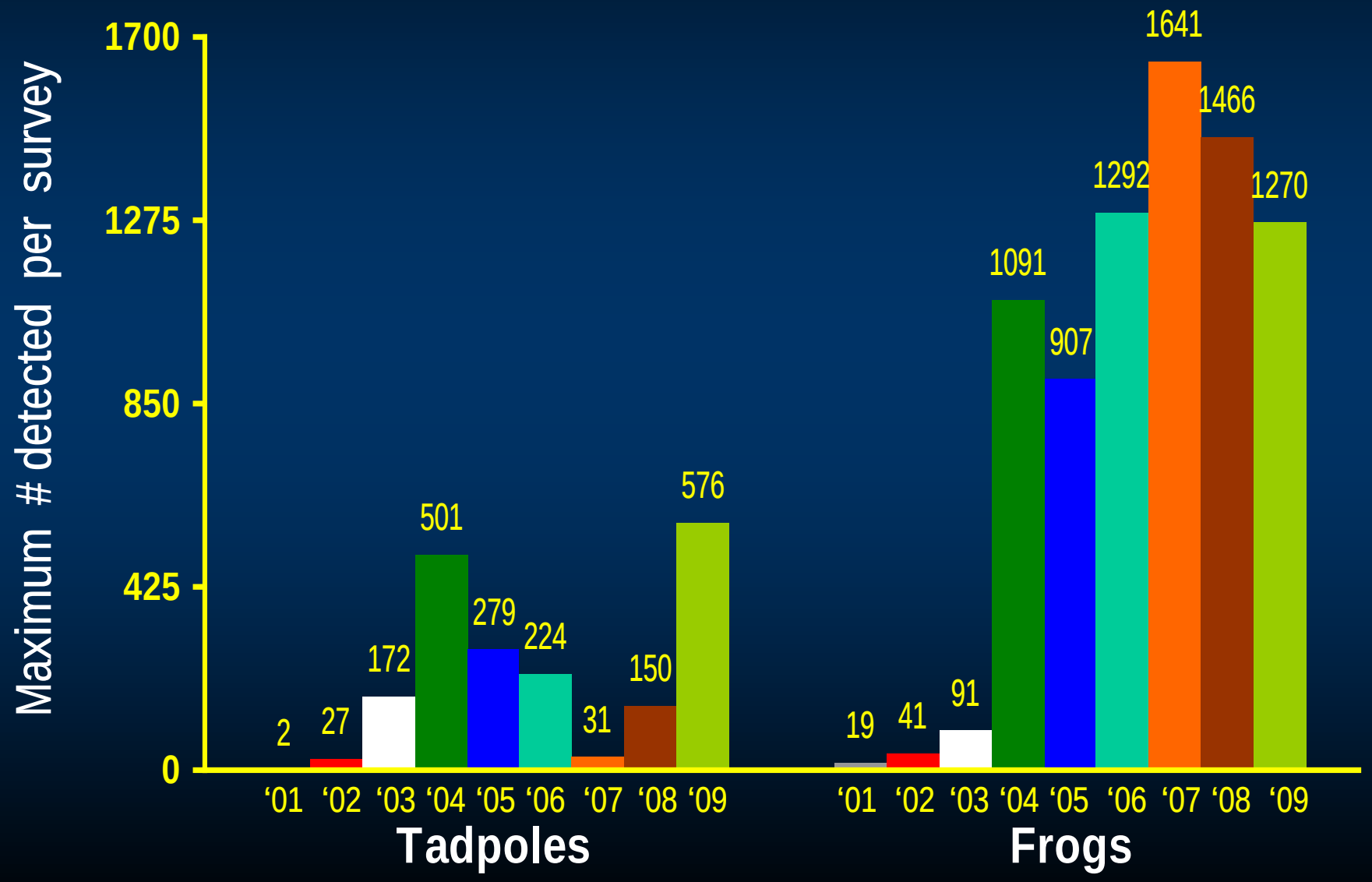
Lake UL-2: MYLFs increased as fish were removed

Fish removal initiated in 2001; 95% removal in 2004



Lake UL-3: MYLFs increased as fish were removed

Fish removal initiated in 2001; 95% removal in 2003



LeConte Restoration Site: # MYLFs Counted Per Year (Frogs Only, No Tadpoles Included)

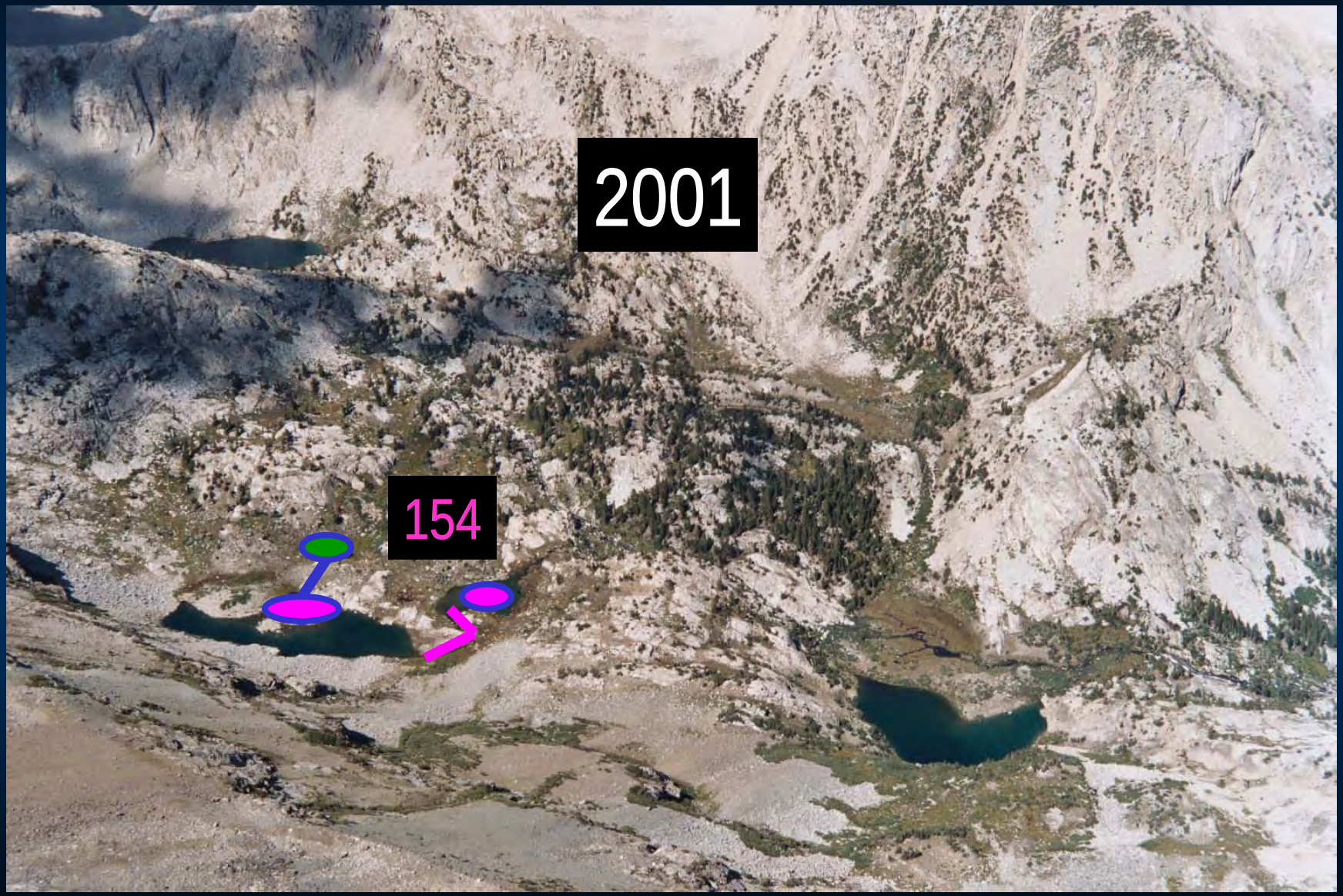


Photo by Danny Boiano, 2003

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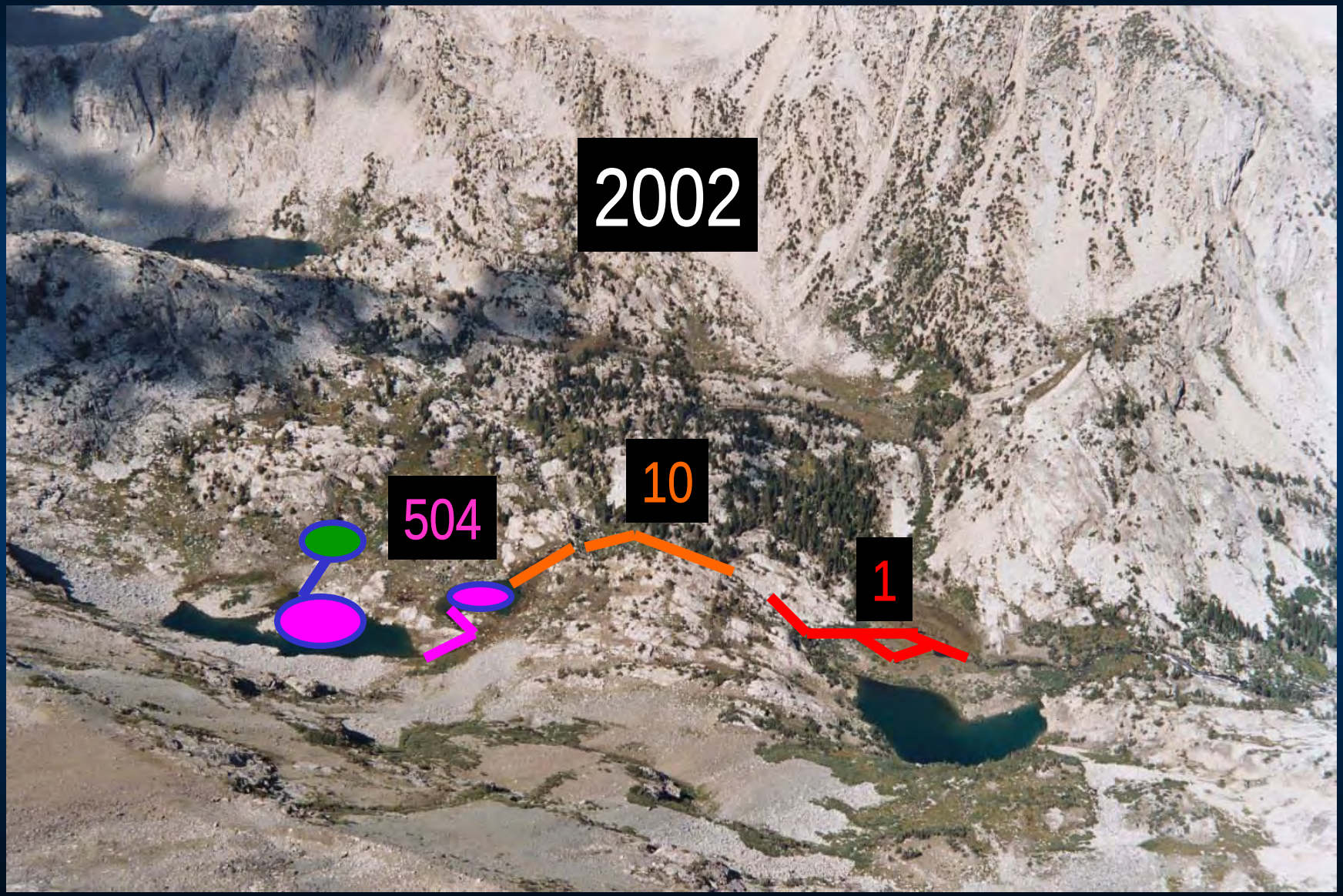

Photo by Danny Boiano, 2003

LeConte Restoration Site: # MYLFs Counted Per Year (Frogs Only, No Tadpoles Included)

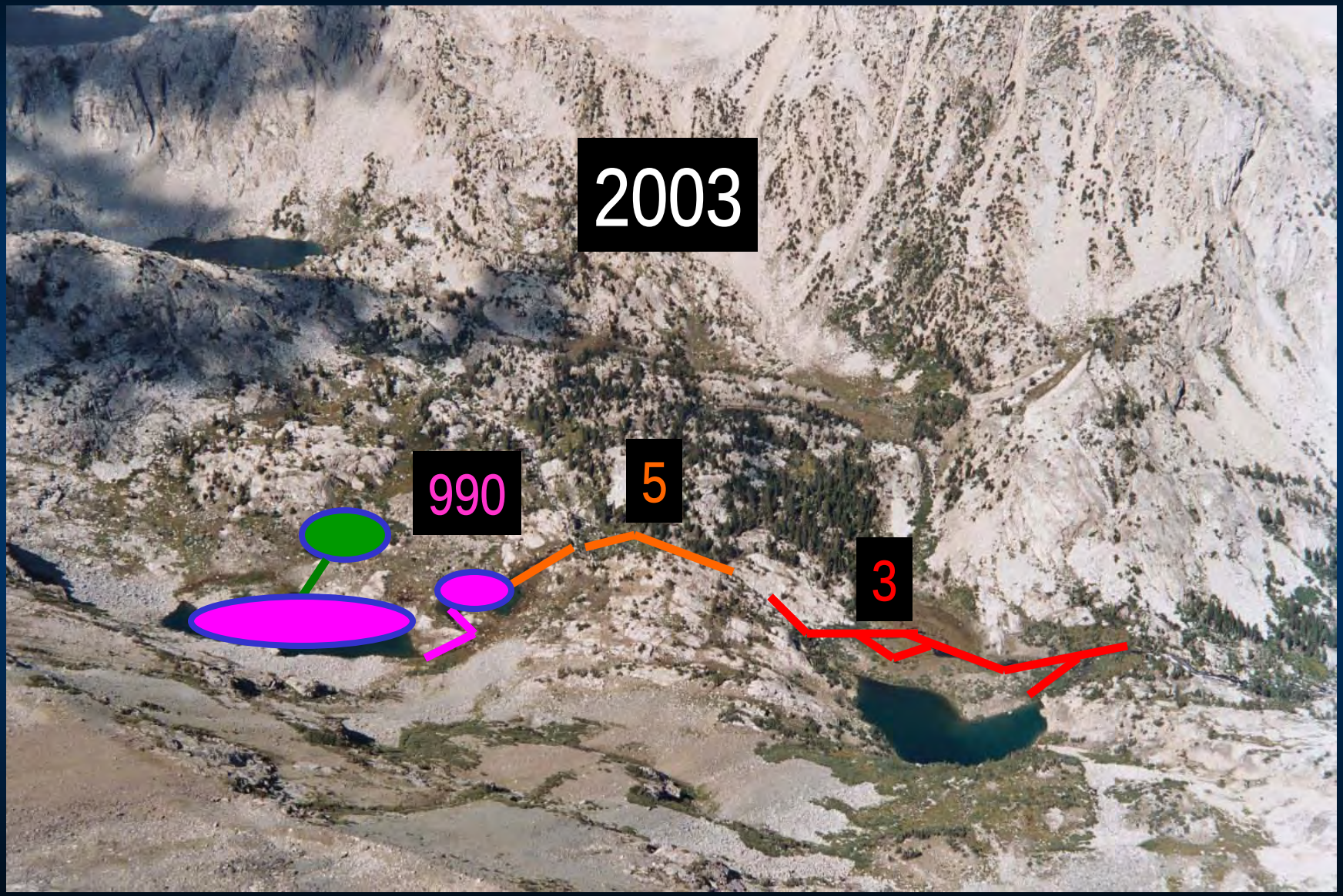

Photo by Danny Boiano, 2003

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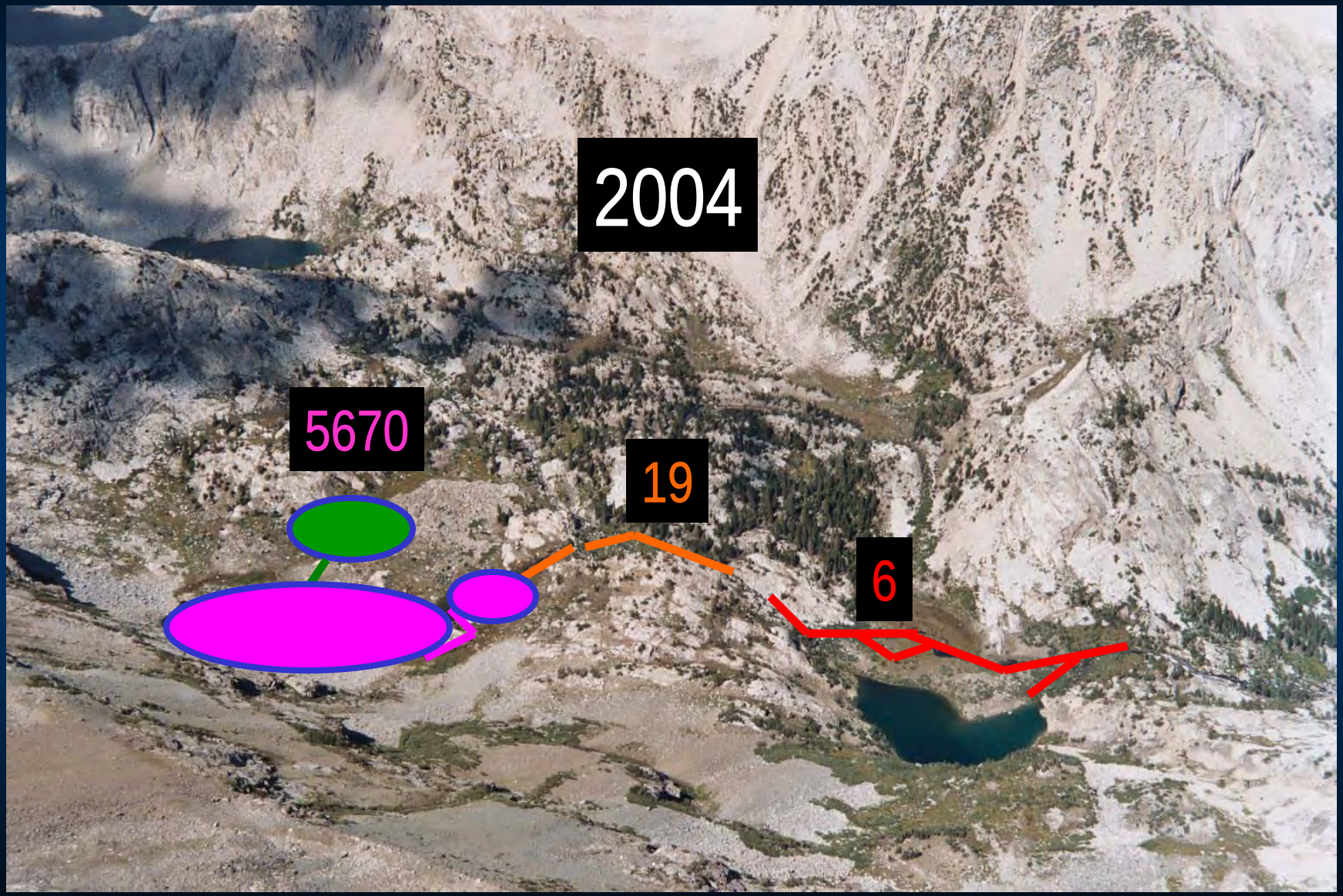

Photo by Danny Boiano, 2003

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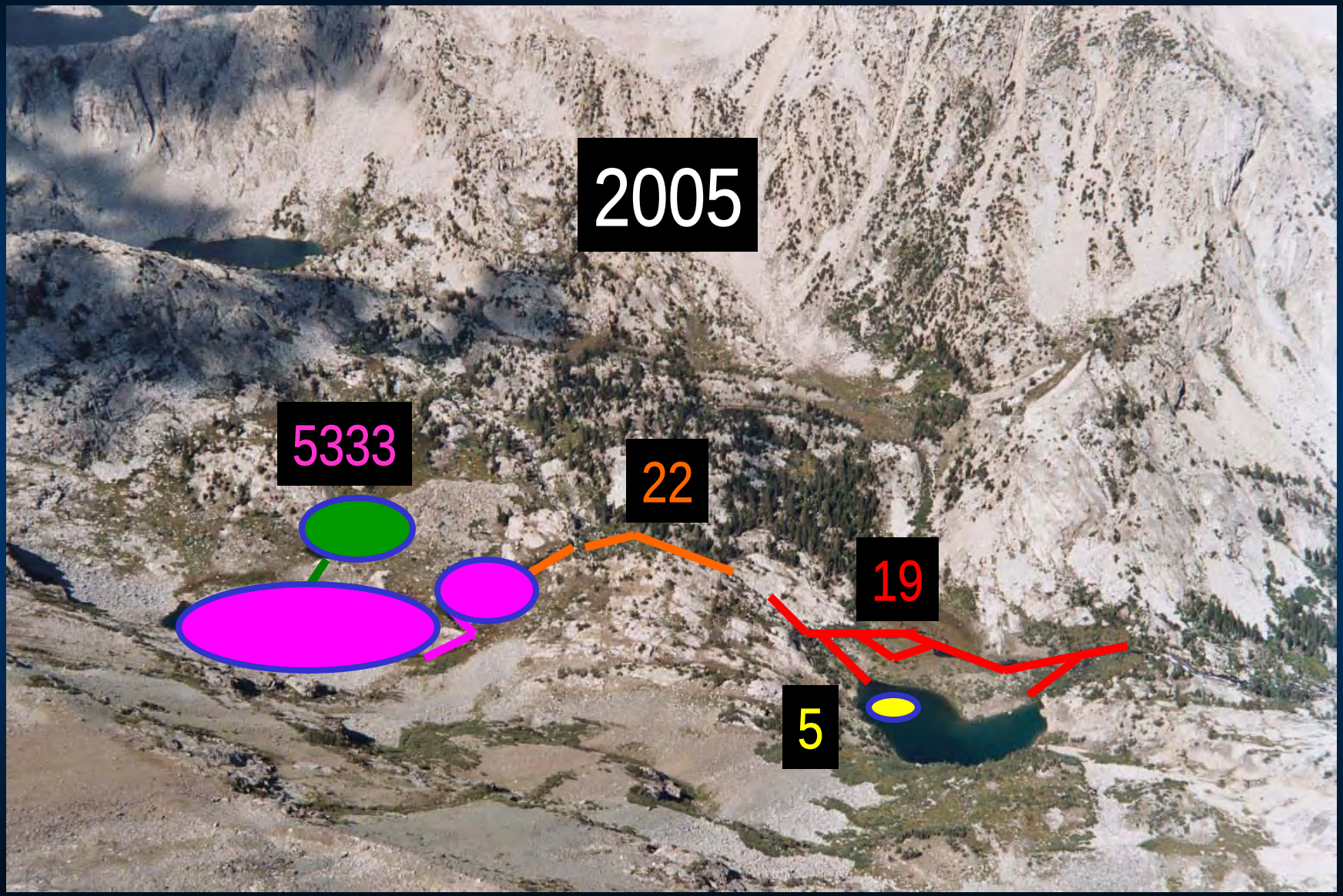

Photo by Danny Boiano, 2003

LeConte Restoration Site: # MYLFs Counted Per Year (Frogs Only, No Tadpoles Included)

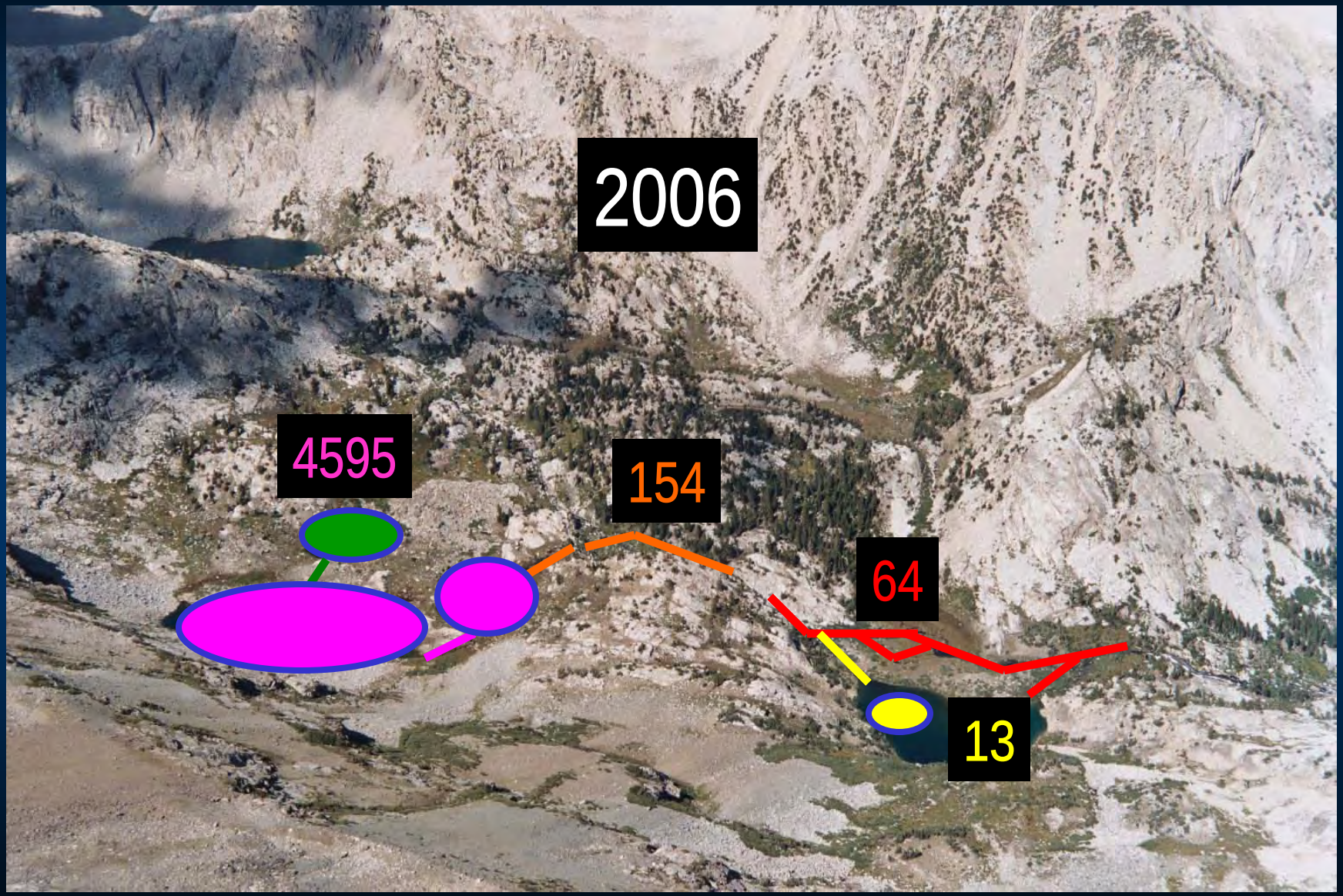

Photo by Danny Boiano, 2003

LeConte Restoration Site: # MYLFs Counted Per Year (Frogs Only, No Tadpoles Included)

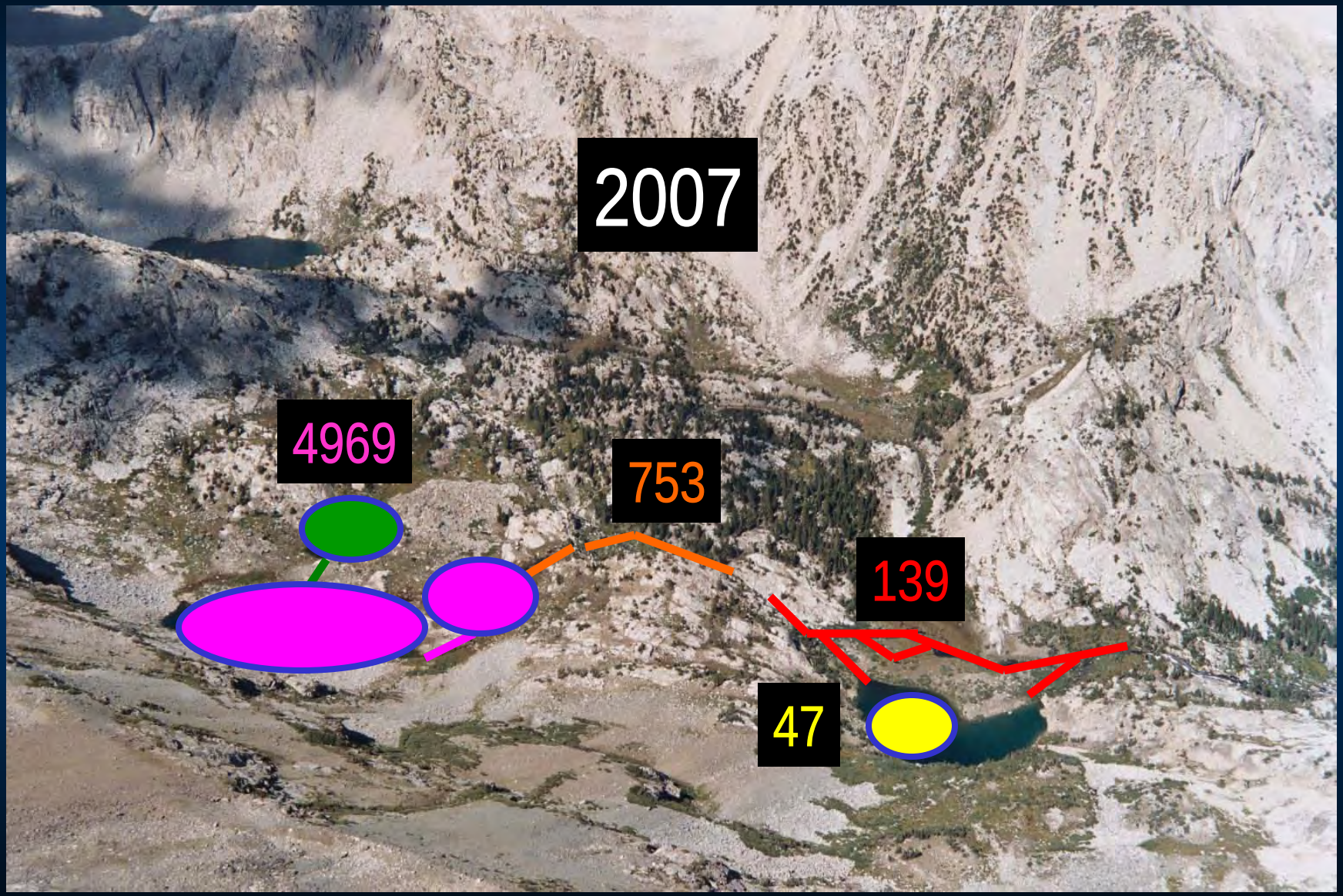

Photo by Danny Boiano, 2003

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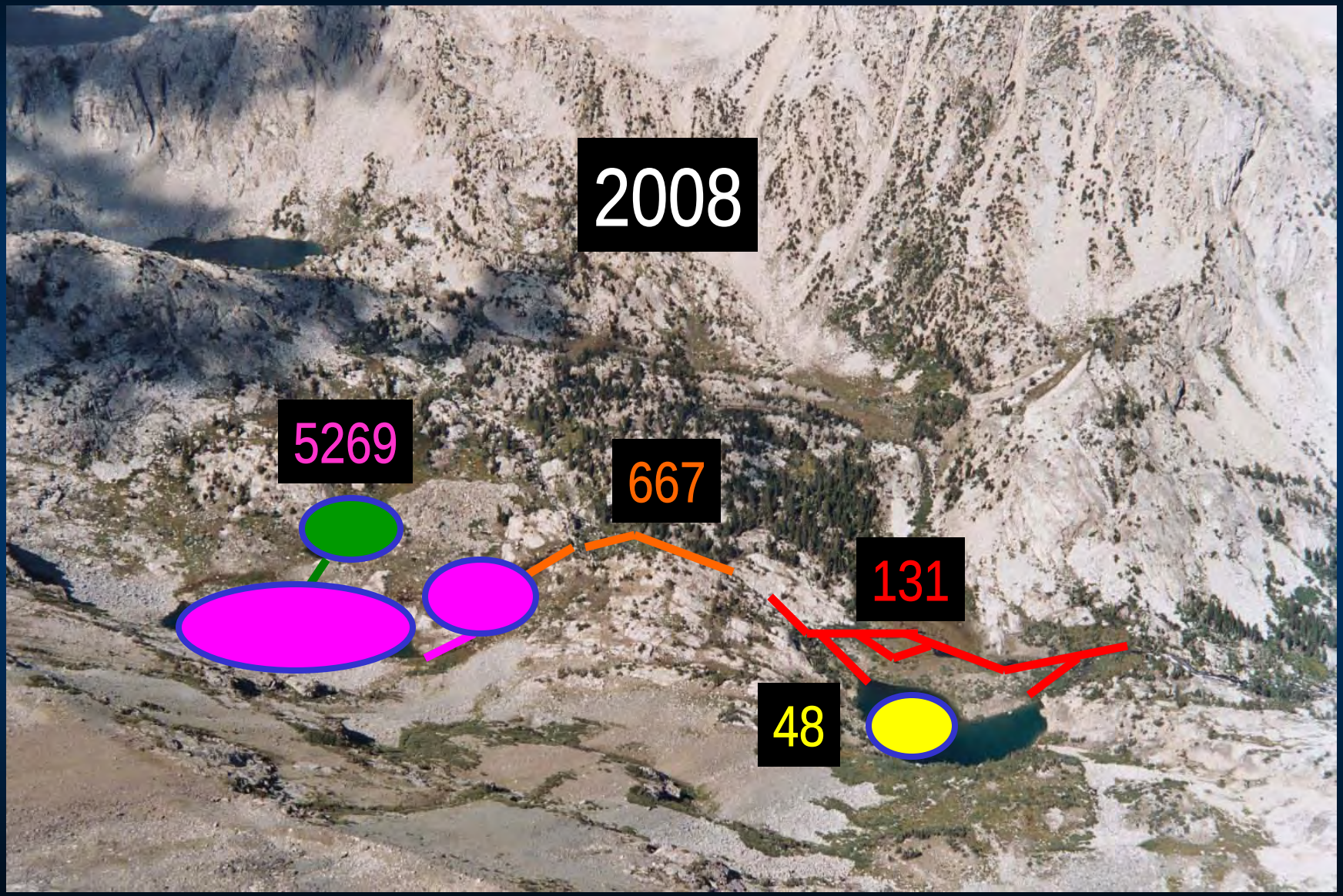

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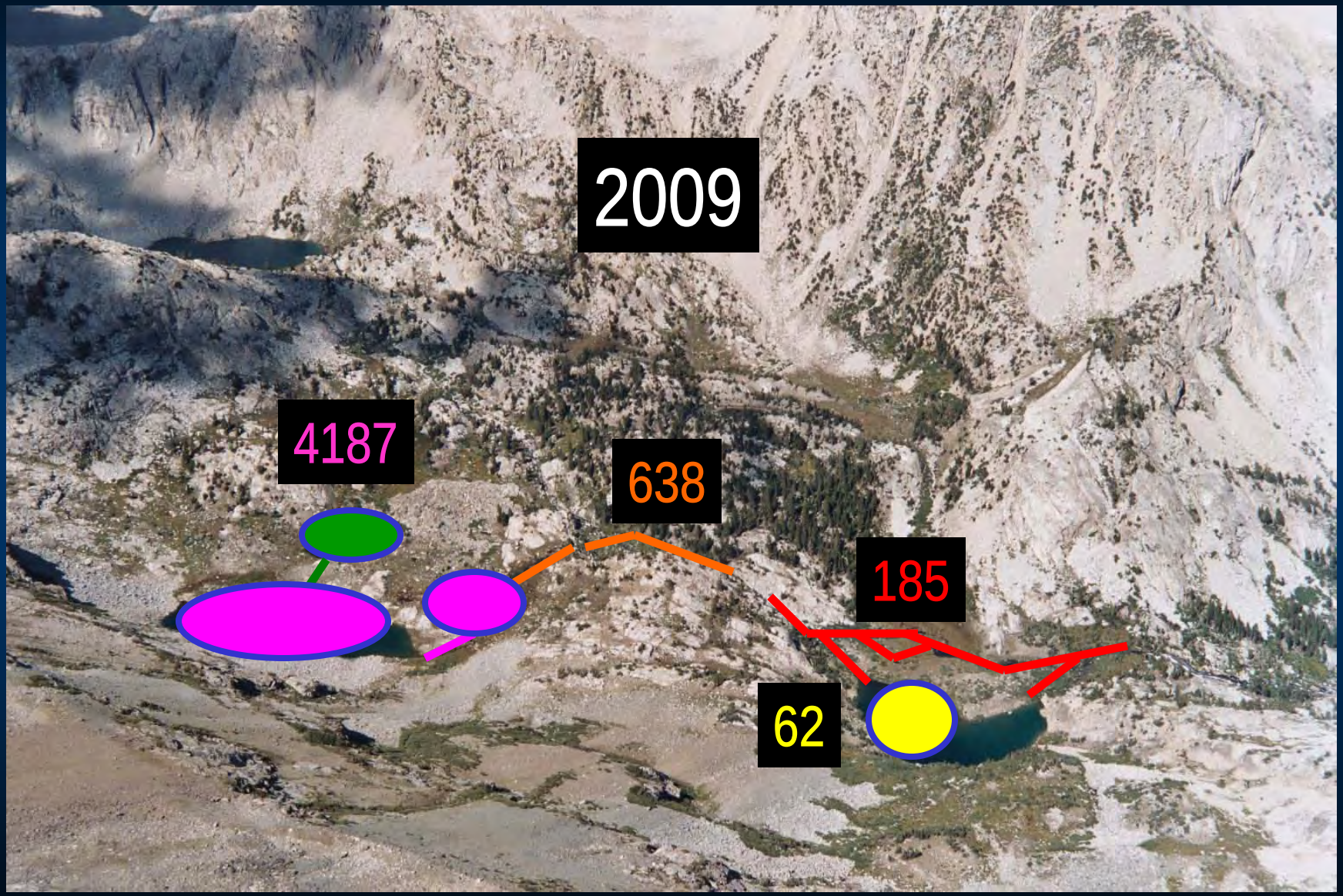
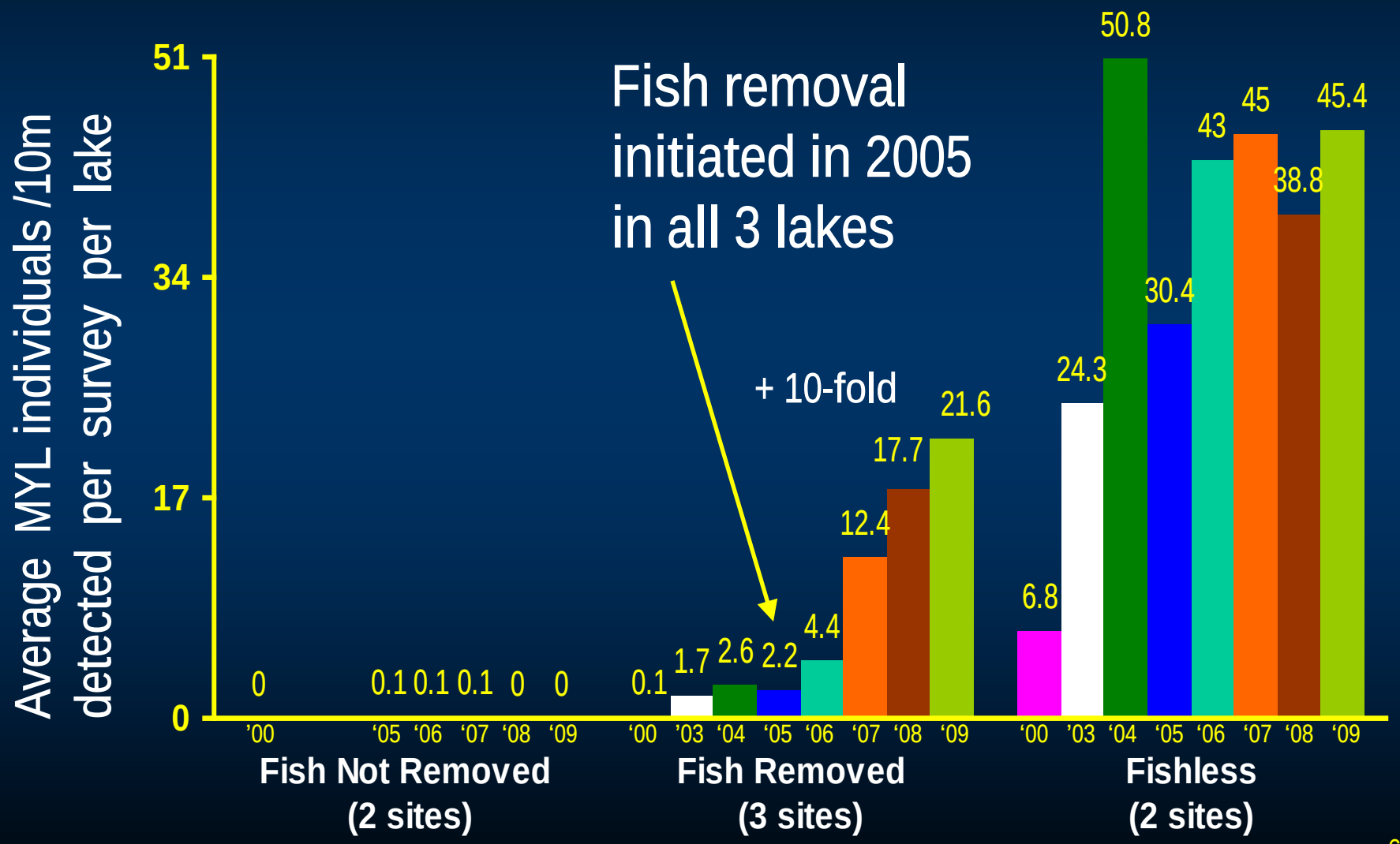


Photo by Danny Boiano, 2003

Upper Bubbs Creek Frog Surveys: 2000-2009

Average MYLF density per survey



Physical Trout Removal Limitations

Gill Netting

- Initial estimate for max. lake area = ~7 acres
- SEKI: ~99% eradicated 11 ac lake (46 ft max depth)
- YOSE: ~99% eradicated 30 ac lake

Electrofishing

- SEKI: ~99% eradicated 1.1 miles of stream
- Idaho Fish & Game: no progress after 3 seasons in 4.9 miles of stream

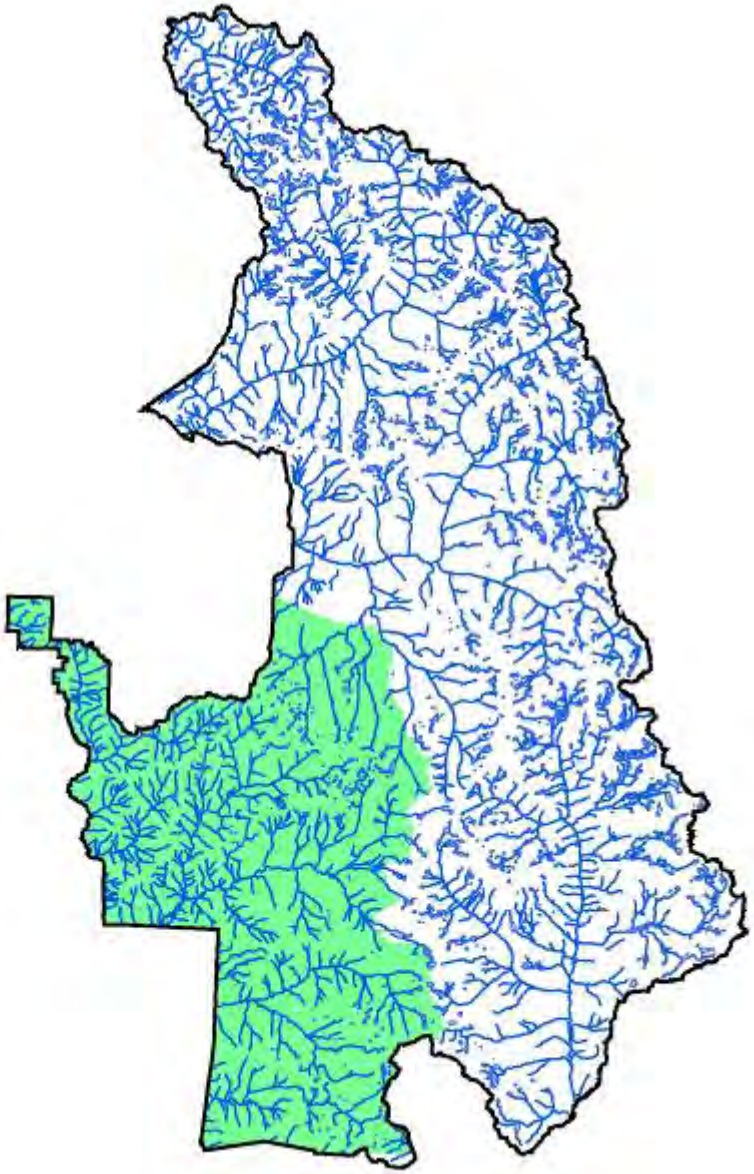
Photos by Melissa Jones, 2007 and Sean Giery, 2002

New Issue - Arrival of the Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*)

- Throughout Sequoia, currently spreading across Kings Canyon.
- Arrival results in population crash, including possible extinction.

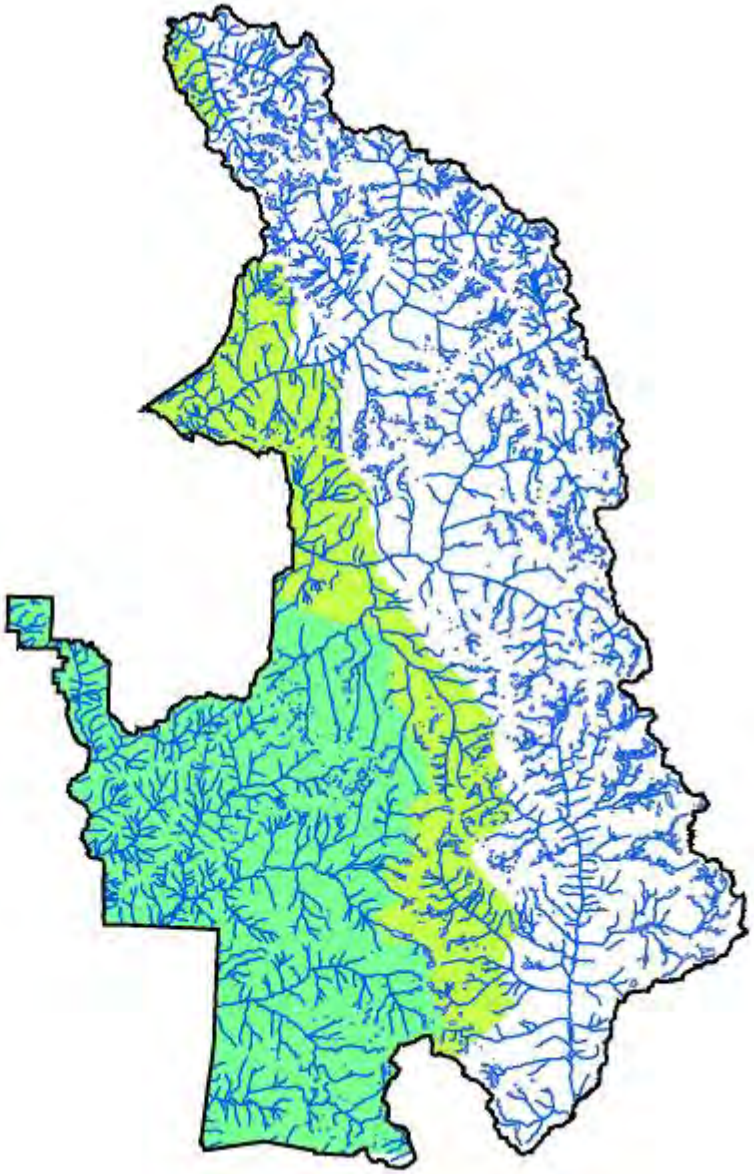
Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

SPREAD OF FUNGUS ACROSS SEKI <1990



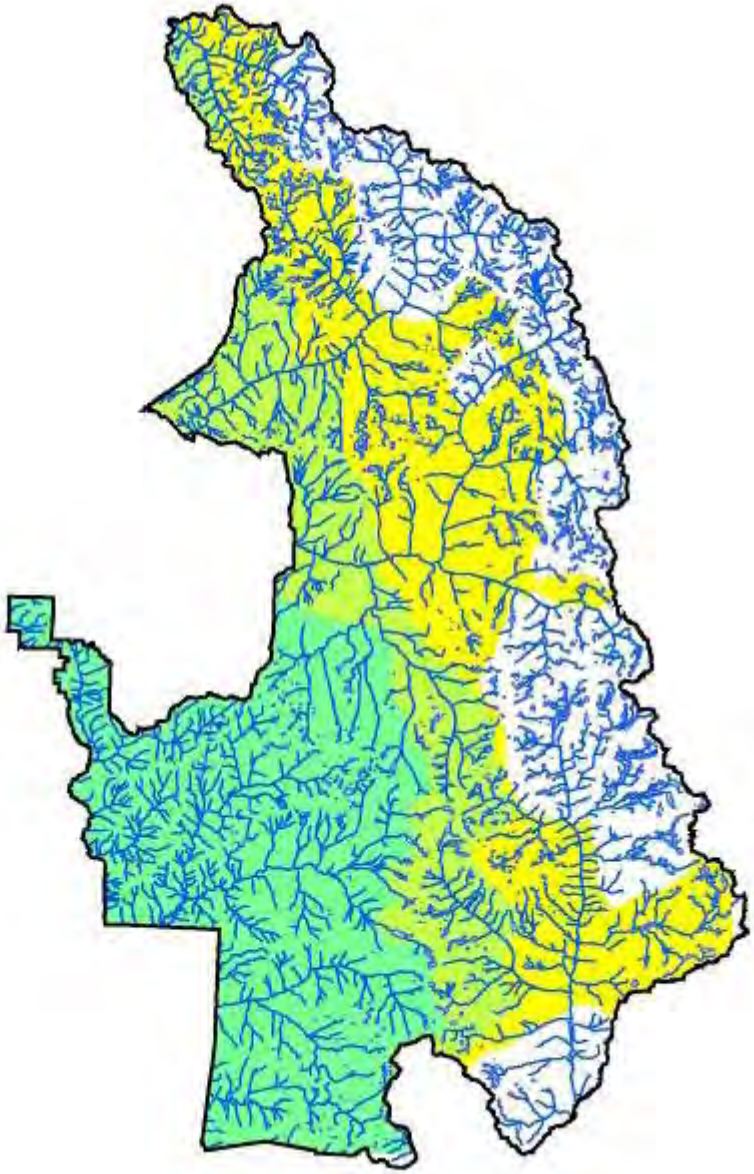
Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

SPREAD OF FUNGUS ACROSS SEKI - 1994



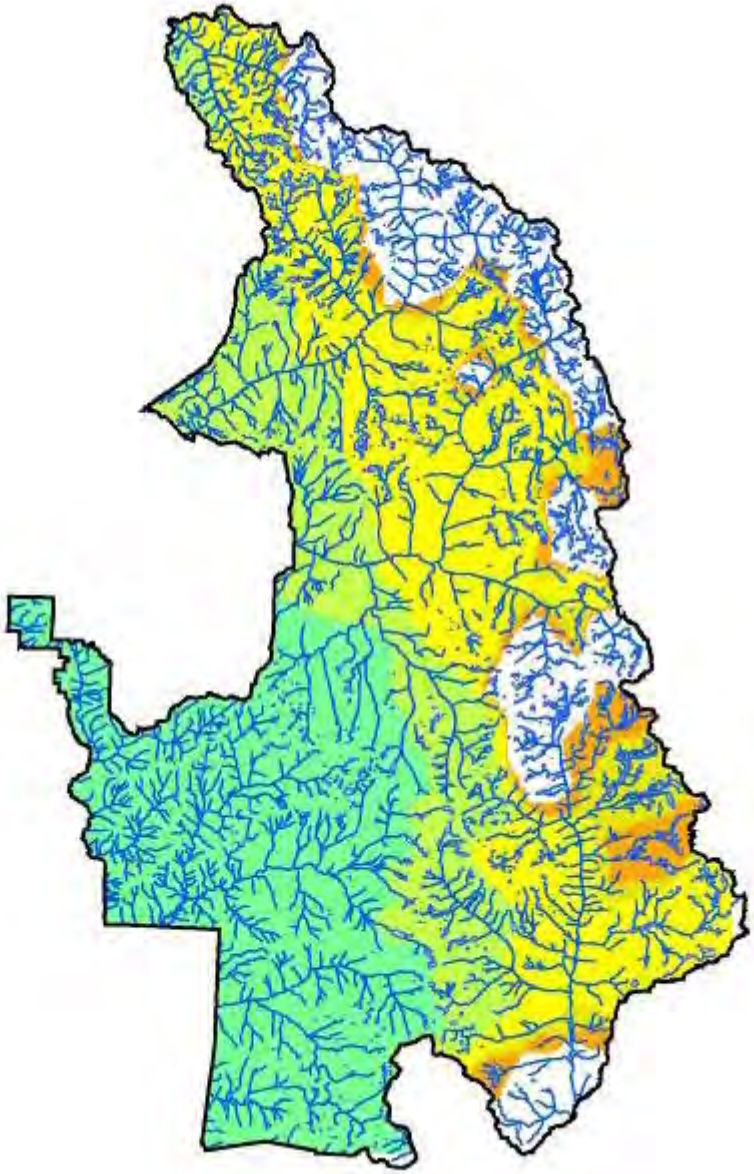
Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

SPREAD OF FUNGUS ACROSS SEKI - 1998



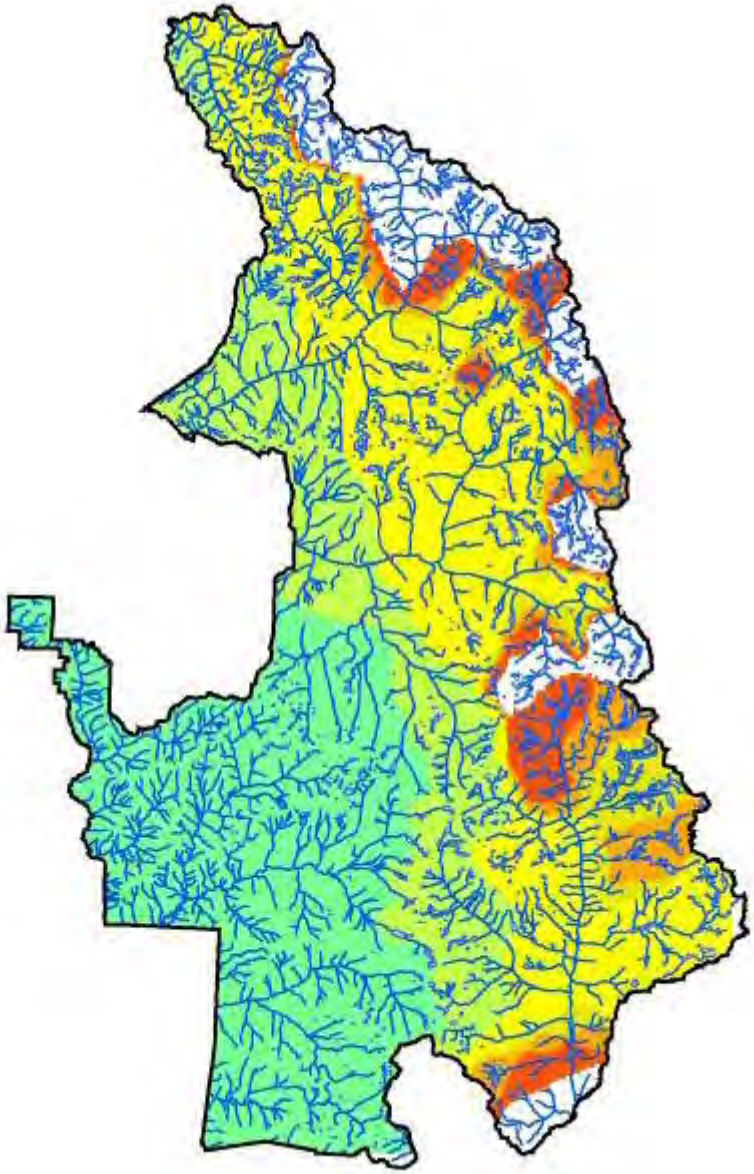
Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

SPREAD OF FUNGUS ACROSS SEKI - 2002



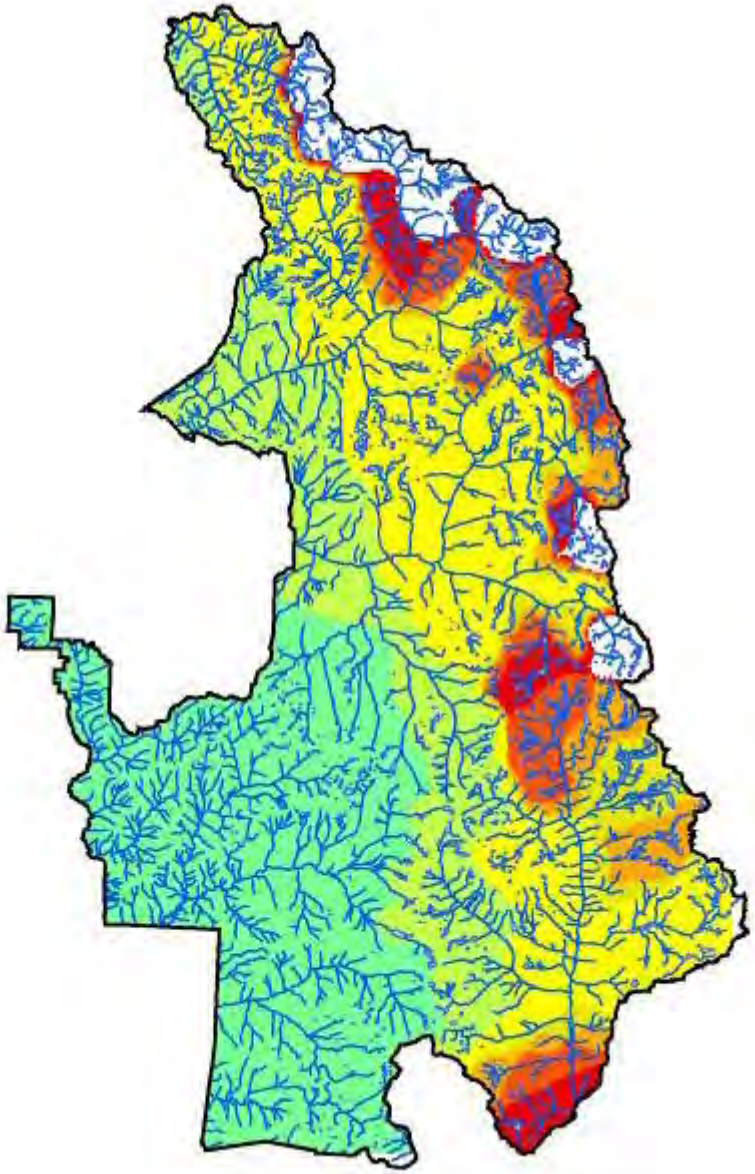
Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

SPREAD OF FUNGUS ACROSS SEKI - 2004



Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

SPREAD OF FUNGUS ACROSS SEKI - 2006



Slide provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

Amphibian Chytrid Fungus

•A few MYLF populations are persisting while infected – all had high abundance upon infection

• LeConte and Bubbs – no restoration sites infected

• 60 Lake Basin - all five restoration sites infected

Photo by Bryan Czibesz, 2004

Will high frog abundance achieved before infection at 2 out of 5 sites help prevent population extinction by chytrid?

More restoration is needed

- While good work is occurring, we are not meeting our mandate to preserve native species and natural ecosystems.
- There is an immediate need to restore more habitat to fishless condition to create large MYLF populations and native refugia.
- Trout removals are beneficial to frogs, other native animals and high elevation aquatic ecosystems.
- Other alternatives need to be considered due to larger scale.

Photo by Danny Boiano, 2002

Objectives of the Proposed Plan/EIS

1. Restore and conserve native species within selected high elevation aquatic ecosystems by creating more favorable conditions for their persistence and resilience.

2. Eradicate non-native trout from up to 75 of these parks' 560 fish-containing lakes and ponds.

3. Prevent widespread loss of ecological function provided by mountain yellow-legged frogs (MYLFs), and conserve their genetic diversity and geographic distribution, by prioritizing restoration to basins with existing or recent populations.

Objectives of the Proposed Plan/EIS (continued)

4. Facilitate research to 1) inform understanding of naturally functioning high elevation aquatic ecosystems and 2) apply science-based restoration and conservation.

5. Use restoration results and new data from research to refine methods and mitigate potential impacts.

6. Collaborate with regional agencies and organizations to strategically restore and conserve native species across the high Sierra Nevada.

Objectives of the Proposed Plan/EIS (continued)

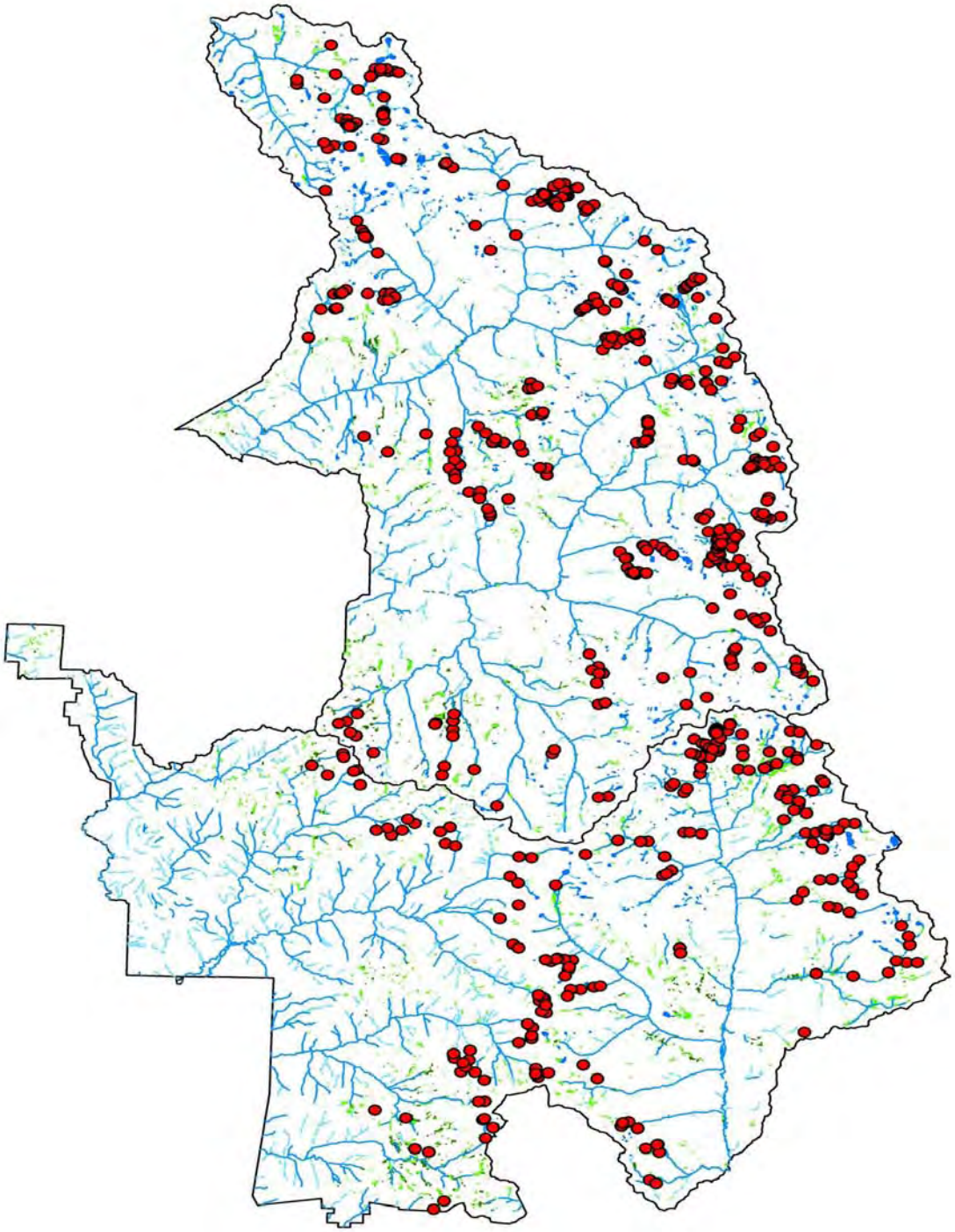
7. Implement plan using a range of management responses derived from a thorough analysis of potential effects to wilderness character and resources.

8. Provide a range of visitor experiences and recreational opportunities at wilderness lakes and streams while minimizing impacts to their biological integrity.

9. Use education to increase awareness of 1) threats to high elevation aquatic ecosystems and 2) associated management responses to restore these systems.

Fish-Containing Water Bodies (~560) in Sequoia and Kings Canyon National Parks

Which basins should be restored?



Draft Criteria for Basin Selection

Favorability Factors	Rule-out or Red-flag Factors
Elevation is above 6,000 feet.	Rule-out: Elevation is below 6,000 feet (Lake basins in SEKI do not occur below this elevation).
Within natural distribution of mountain yellow-legged frogs (evidence of current or recent populations; includes sites where frogs recently died out due to disease).	Red-flag: There is no evidence of current or past mountain yellow-legged frog populations (removal of trout would still benefit other native species).
Conserves genetic diversity of mountain yellow-legged frogs within SEKI (several sites restored within each of three genetic clades).	Red-flag: Total number of restoration sites is imbalanced with respect to genetic diversity of mountain yellow-legged frogs within SEKI.
Conserves spatial representation of mountain yellow-legged frogs within SEKI (sites restored across park latitudes and longitudes).	Red-flag: Total number of restoration sites is imbalanced with respect to spatial representation of mountain yellow-legged frogs within SEKI.
Groupings of waterways appropriate for treatment: In basins in which some fish lakes would remain, the restoration lakes would need to be at top of basin. Several entire basins are restored, spread across SEKI.	Red-flag: Groups of waterways not considered appropriate for treatment would include basins in which some fish lakes would remain and the restoration lakes would be at middle or bottom of basin.
Adequate downstream barrier (large waterfall or long, steep cascade) exists to prevent fish from recolonizing restoration area. Barrier adequacy would be assessed prior to onset of restoration.	Rule-out: No adequate downstream barrier exists. Fish are observed breaching all possible barriers.

Draft Criteria for Basin Selection (Continued)

Favorability Factors	Rule-out or Red-flag Factors
Restoration is feasible from a logistical standpoint. Habitat structure would allow trout eradication without extreme difficulty, and site is accessible by field crews.	Rule-out: Restoration is considered infeasible from a logistical standpoint. Habitat structure is so complex that it would be extremely difficult to eradicate trout, and/or site cannot be safely accessed by field crews.
For individual lake selection, recreational fishing value of lake is considered to be medium to low (not an extremely popular or trophy fishery). For the overall project, fishing opportunities within SEKI continue to exist that satisfy a range of visitor values, including multiple lakes: 1) near trailheads for easy access 2) in remote basins for solitude 3) having large fish for a trophy experience 4) having lots of fish for a high-catch experience	Red-flag: For individual lake selection, recreational fishing value of lake is considered to be high (an extremely popular or trophy fishery). For the overall project, multiple fish lakes within each of the following categories do not continue to exist within SEKI: 1) near trailheads for easy access 2) in remote basins for solitude 3) having large fish for a trophy experience 4) having lots of fish for a high-catch experience
Crew presence would not adversely affect threatened or endangered plants or wildlife.	Red-flag: Crew presence would adversely affect threatened or endangered plants or wildlife.
Other known threats are not an issue.	Red-flag: Other threats make site less desirable. For example, considering piscicide use in areas close to human populations.

Description of GIS Maps

- clade - a group of organisms that share features inherited from a common ancestor
- Vredenburg and others (2007) determined MYLFs comprise 2 species: *Rana sierrae* & *Rana muscosa*
- Each species contains 3 distinct clades, based on genetic makeup, morphology, and vocalization
- Both species and 3 clades exist within SEKI
- Maps show lake areas conceptually proposed for:
  1) physical trout eradication - in purple
  2) chemical trout eradication - in red
  3) MYLF conservation in fishless areas - in orange
  4) examples fishing lakes tentatively removed from restoration consideration - in yellow

Rana sierrae

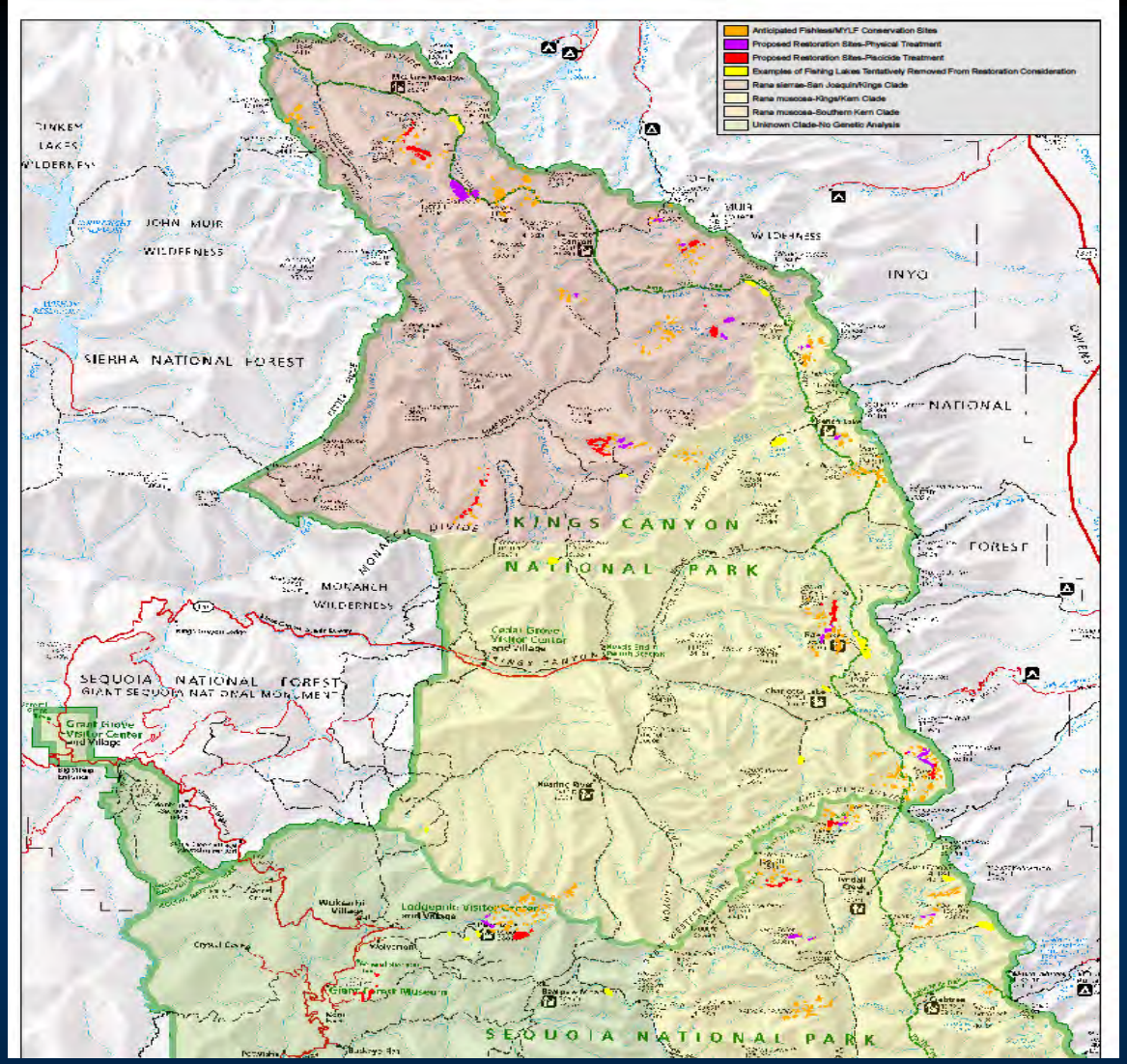
Rana muscosa

Photos provided by Dr. Roland Knapp, Sierra Nevada Aquatic Research Lab, CA

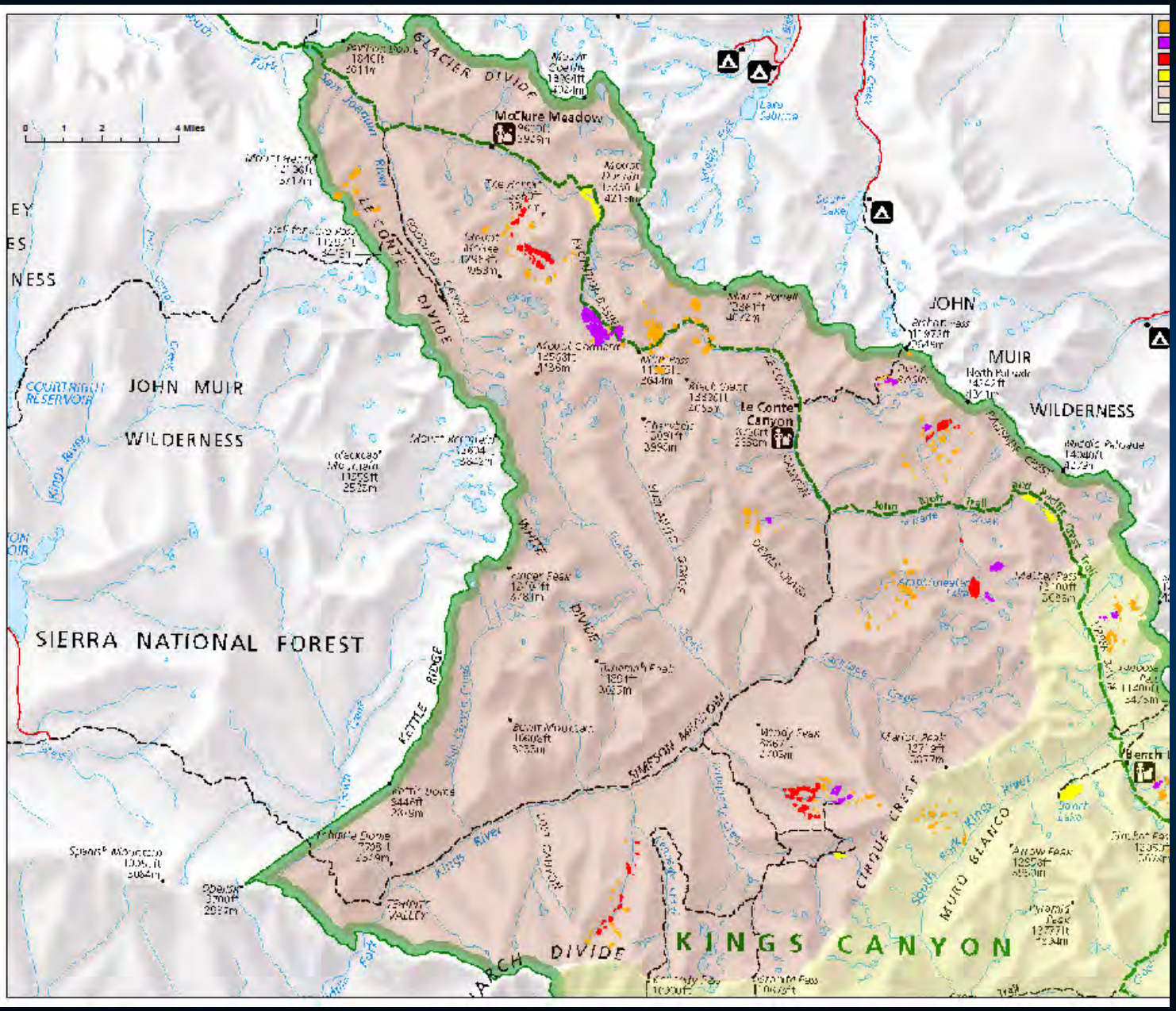
OVERVIEW MAP:

Conceptual Restoration & Conservation Water Bodies (Alternative B)

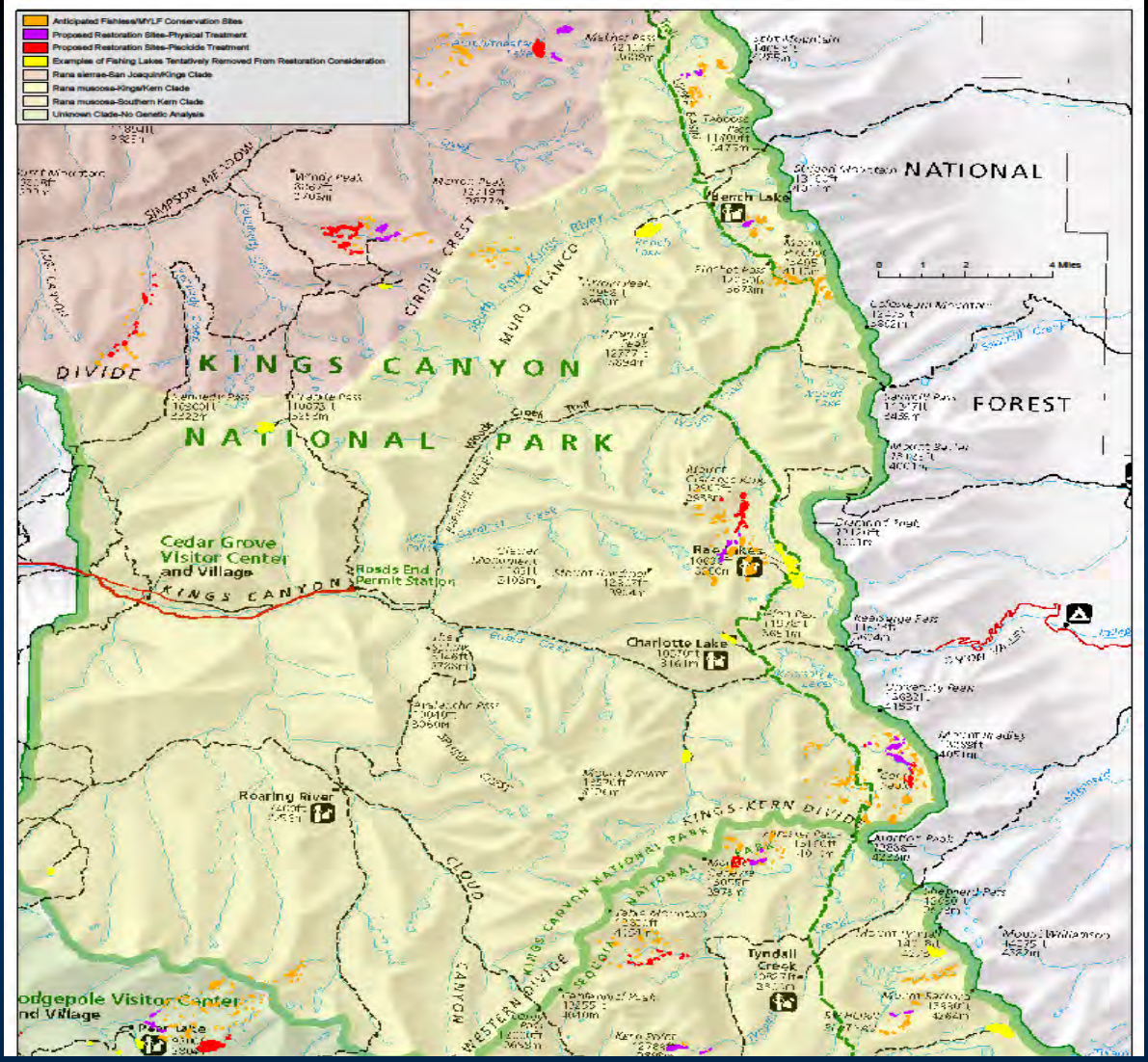
& Examples of Fishing Lakes Tentatively Removed from Restoration Consideration



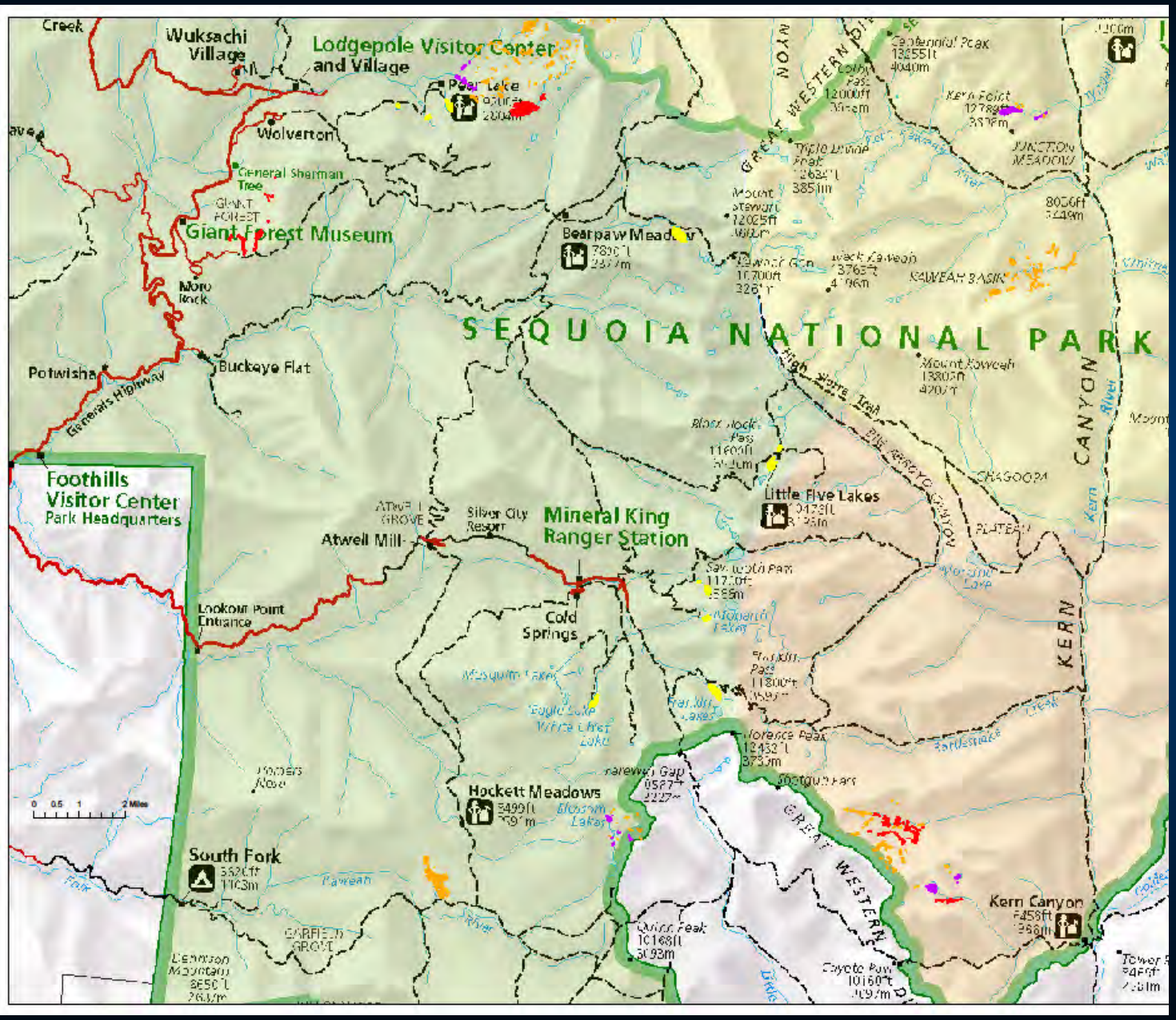
SAN JOAQUIN/KINGS MYLF CLADE MAP



KINGS/KERN MYLF CLADE MAP



SOUTHERN KERN MYLF CLADE MAP



Conceptual Alternative B – Prescription Treatment Preceding Restoration

- Approximately 25 to 28 new basins restored
- Trout eradicated from ~73 water bodies in 20 basins
- Native species conserved in or restored to currently fishless waters in up to 28 basins.
- Eradication sites represent ~13% of the parks' ~560 lakes, ponds, and wetlands known to contain fish.
- ~485 self-sustaining fishing waters would remain
- Treatment would include trout eradication by gill netting and electrofishing at all sites where feasible
- And using piscicides at sites determined in-feasible for other treatment methods

Photos by Danny Boiano, 2002; below from Rotenone Use in Fisheries Management, AFS 2000

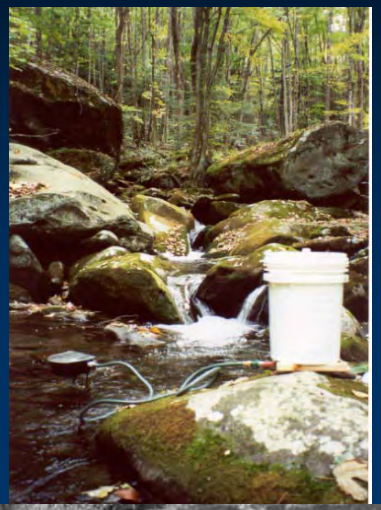
Conceptual Alternative C – Physical Treatment Preceding Restoration

- Approximately 22 to 25 new basins restored
- Trout eradicated from ~32 water bodies in 15 basins
- Native species conserved in or restored to currently fishless waters in up to 25 basins.
- Eradication sites represent ~6% of the parks' ~560 lakes, ponds, and wetlands known to contain fish.
- ~525 self-sustaining fishing waters would remain
- Treatment would include trout eradication by gill netting and electrofishing at all sites where feasible

Photos by Danny Boiano, 2002

Conceptual Alternative D – Chemical Treatment Preceding Restoration

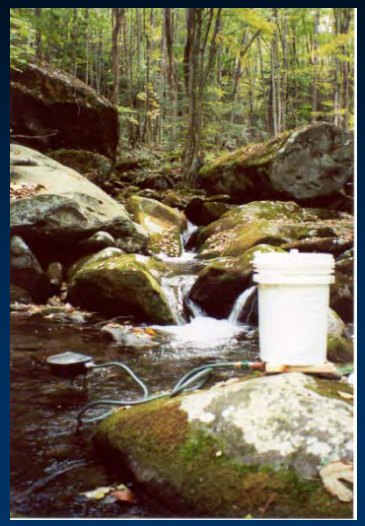
- Approximately 25 to 28 new basins restored
- Trout eradicated from ~73 water bodies in 20 basins
- Native species conserved in or restored to currently fishless waters in up to 28 basins.
- Eradication sites represent ~13% of the parks' ~560 lakes, ponds, and wetlands known to contain fish.
- ~485 self-sustaining fishing waters would remain
- Treatment would include trout eradication using piscicides



Piscicide applications in streams (above from GRSM NP Antimycin Fact Sheet; below from Rotenone Use in Fisheries Management, AFS 2000)

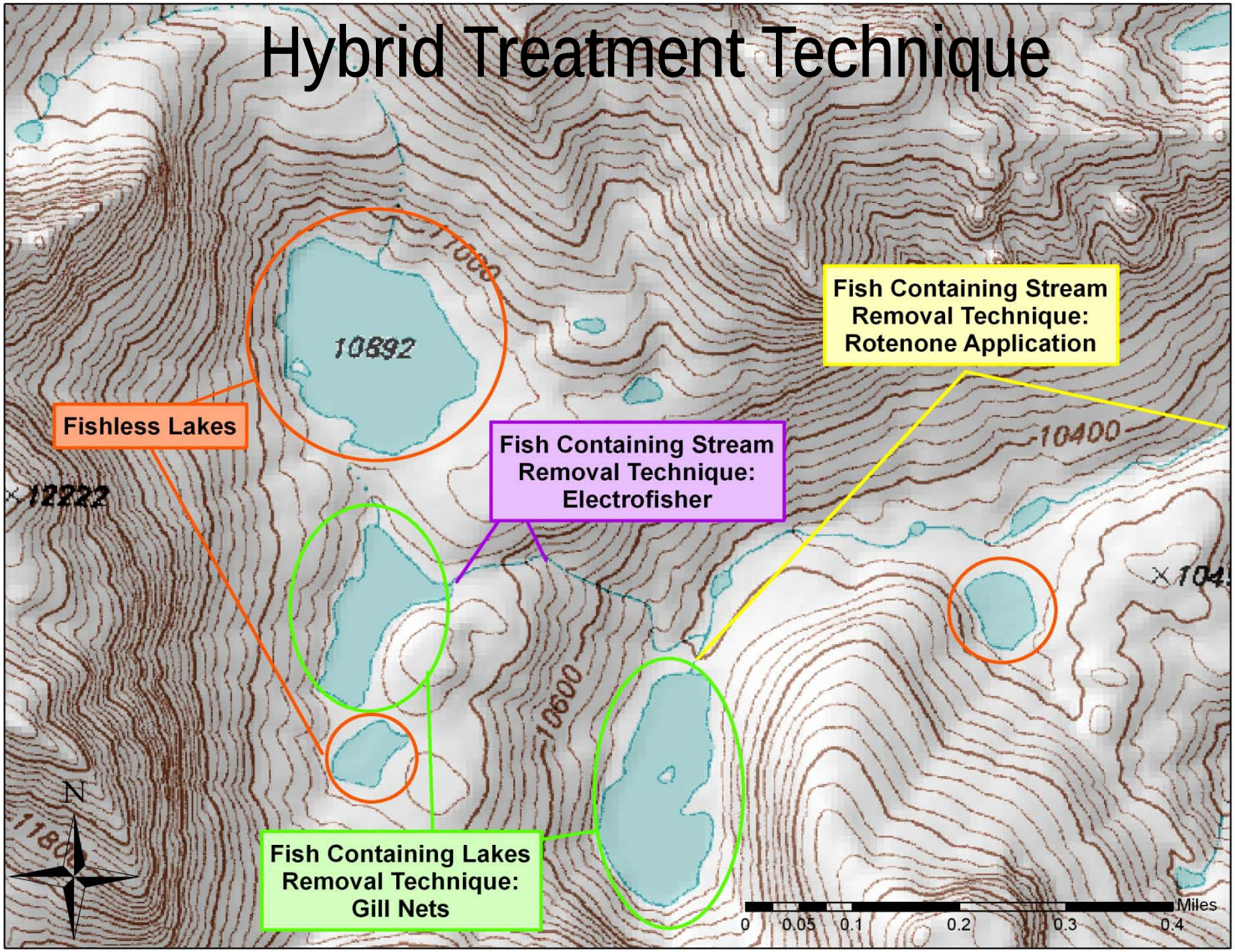
Restoration tool under consideration – Fish eradication using piscicides

- Toxic to gill-breathing organisms: disrupts respiration at extremely low concentrations
- Use is highly regulated by USEPA - specific instructions required for piscicide applications
- Applications limited to low concentrations
- Degrade rapidly into non-toxic components and do not persist or bioaccumulate
- Neutralized with potassium permanganate



Piscicide applications in streams (above from GRSM NP Antimycin Fact Sheet; below from Rotenone Use in Fisheries Management, AFS 2000)

Hybrid Treatment Technique



SEKI needs to restore native populations as quickly as possible, creating robust sites like below in several basins across the park.

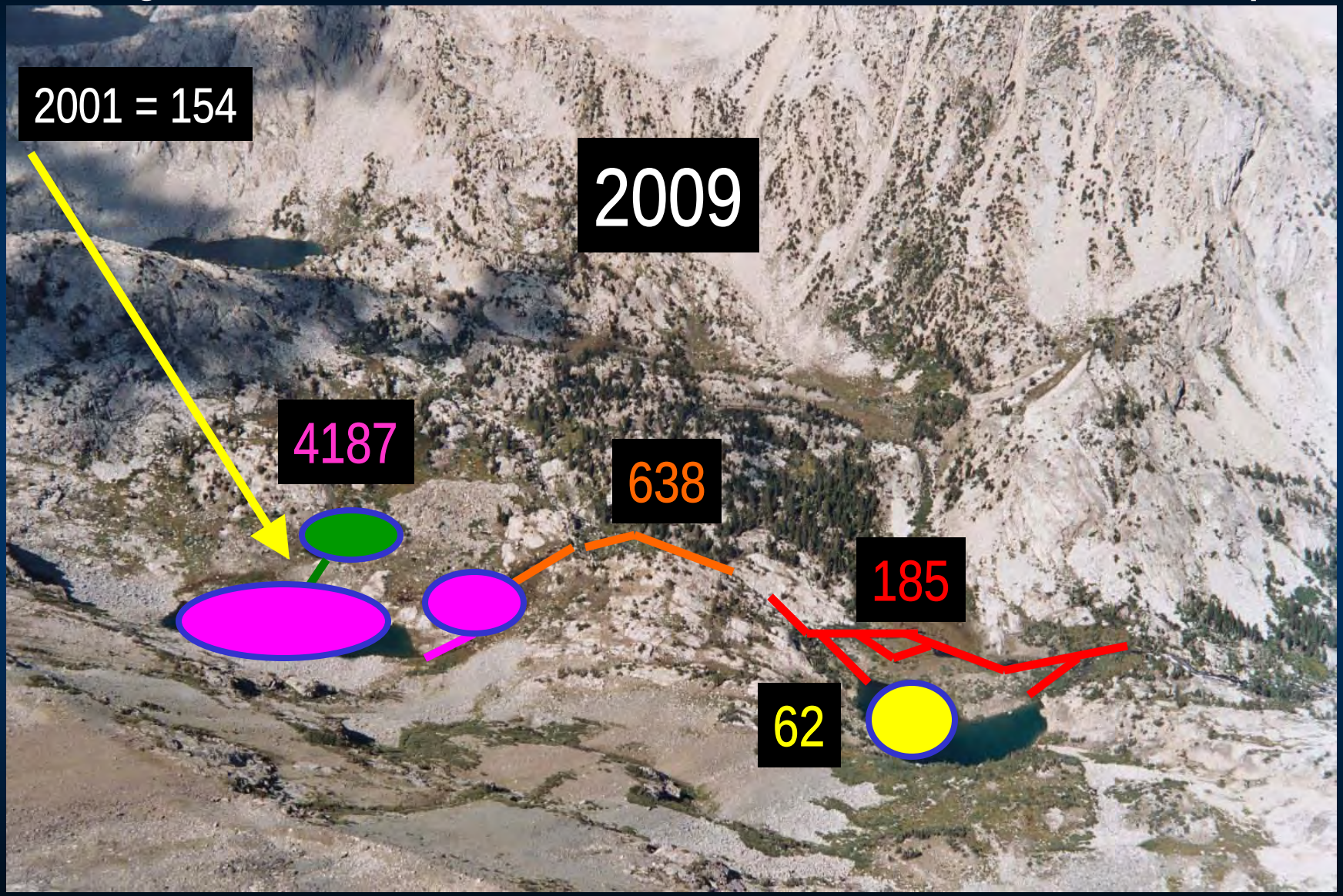


Photo by Danny Boiano, 2003

Recreational angling opportunities will continue to be available in hundreds of lakes and ponds across SEKI.

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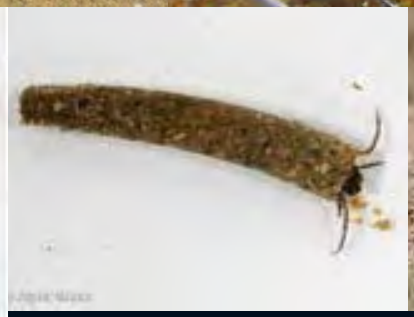
Expanding restoration program will protect native species diversity across SEKI and increase resiliency of native populations to uncertain future conditions



Photos by Danny Boiano (1997), Bryan Czibesz (2004), and from CalPhotos.