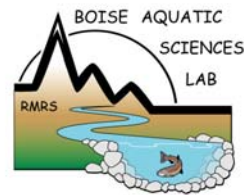


Use of Thematic Mapper Satellite Imagery, Hemispherical Canopy Photography, and Digital Stream Lines to Predict Stream Shading

David Nagel – GIS Analyst

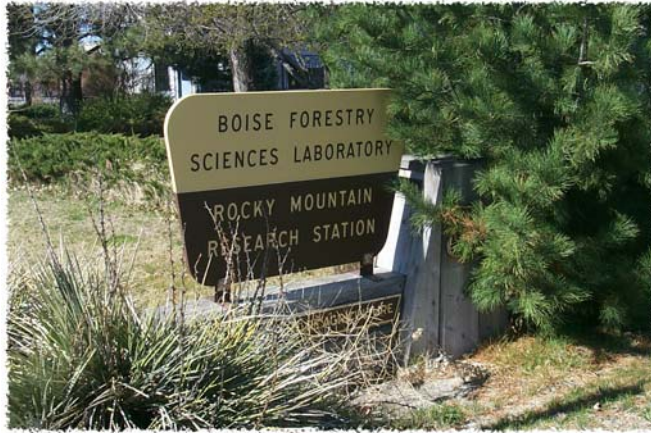
Charlie Luce – Research Hydrologist

Bárbara Gutiérrez Teira – Post Doctoral Research Biologist



Title slide. Presentation delivered in September, 2004.

Boise Aquatic Sciences Lab



This research was conducted by scientists and analysts at the U.S. Forest Service, Boise Aquatic Sciences Lab, Boise, ID.

Middle Fork Boise River Watershed

Boise National
Forest



0 10 20
Kilometers

The study area is located in central Idaho, encompassing the Middle and North Forks of the Boise River watershed.

Boise Lab Disciplines



Fisheries



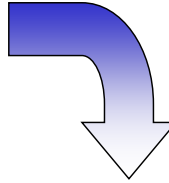
Watershed

Studies at the Boise Lab often focus on the interactions between biological and physical sciences.

Stream Temperature



Physical



Biology

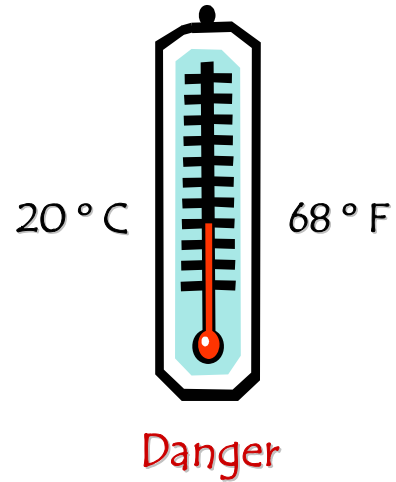


Stream temperature research exemplifies the importance of linking biological and physical sciences.

Rationale



Threatened Bull Trout



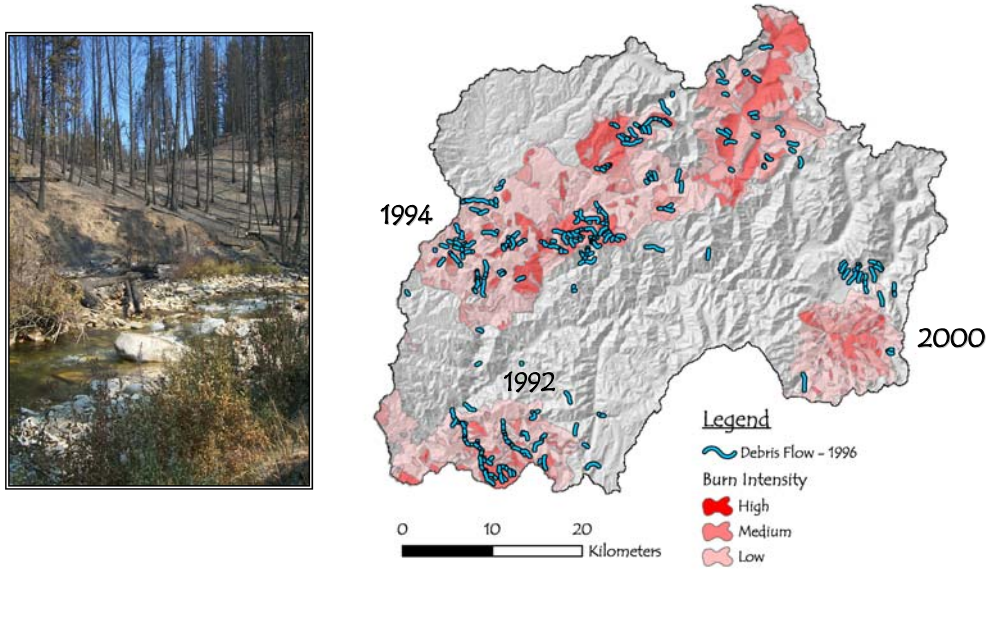
Stream temperature research is important for developing management plans for thermally sensitive species such as bull trout.

Disturbance



Disturbances such as fire and debris flows are an important part of the physical template that influences biology.

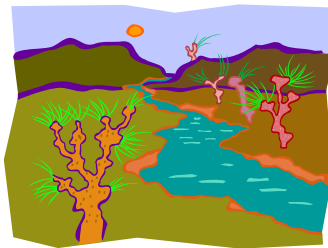
Disturbance 1992-2000



This graphic illustrates the extent of disturbance due to fire and debris flows within our study area.

Objective

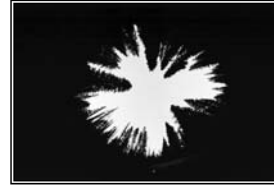
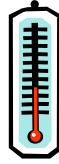
Estimate incident solar radiation at the stream surface, at the landscape scale, to help understand observed differences in water temperature



The study objective.

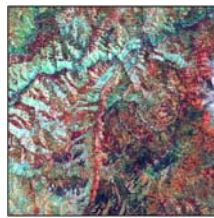
Shade Study Components

1) Instream temperature

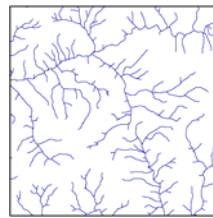


2) Canopy photography

3) Satellite imagery/DOQ



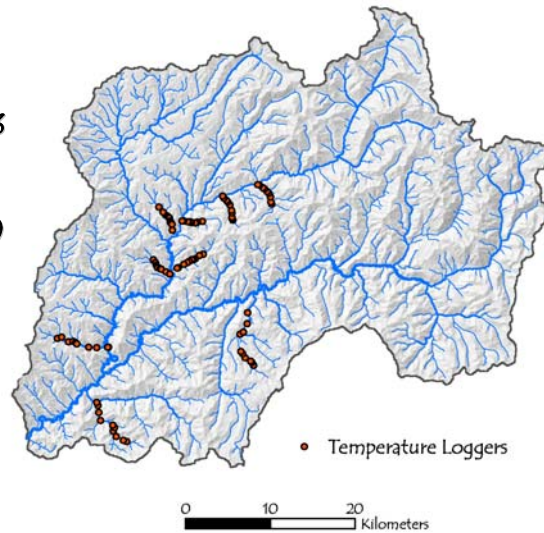
4) Stream lines



The study incorporates four important data collection components. We assume that instream temperatures are influenced by shade. Shade (radiation) was mapped using satellite imagery and estimated along the stream channel.

Instream Temperature

- ◊ Collected during summer 2003
- ◊ July - September
- ◊ Ten streams x ten loggers (100)



Instream temperatures were collected between July and September in 10 streams, with 10 thermographs in each stream.

Streams and Mean Temperature

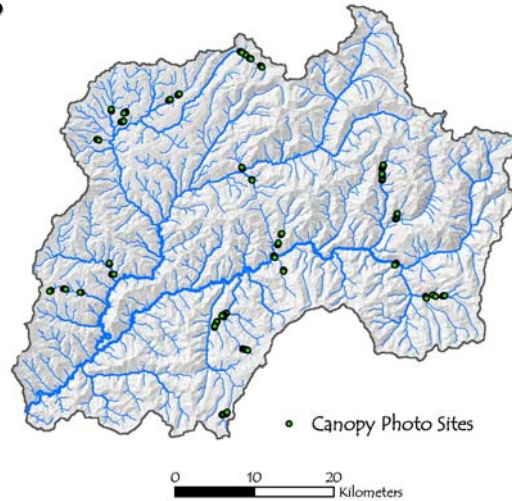
Beaver	9.49 ° C
Lost Man	9.65
Hungarian	10.27
French	10.82
Trail	11.32
Lost	13.69
SF Sheep	13.71
Cottonwood	13.71
Trapper	14.13
Wren	15.55



This is a list of the study streams and their summer mean temperatures. Tidbit Temperature Loggers were used.

Canopy Photography

- ◇ Collected summer 2003
- ◇ 181 photos
- ◇ Differential GPS
- ◇ Horizontal photos



We also collected hemispherical canopy photography throughout the study area. Our objective was find a relationship between radiation predictions derived from canopy photos and stream temperature.

Hemispherical Canopy Photography

- ◊ Sites distributed among different vegetation types and stream sizes
- ◊ Processed photos using Hemiview software
- ◊ Total June radiation, direct and diffuse
- ◊ Radiation values range from 118 – 1038 MJ/m²yr
- ◊ Collected horizontal photos



Specifics regarding canopy photography.

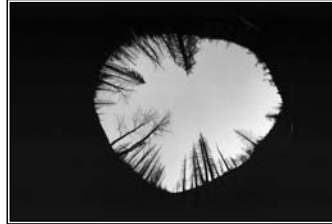
Canopy Photography and Horizontals

Radiation
(MJ/m²yr)

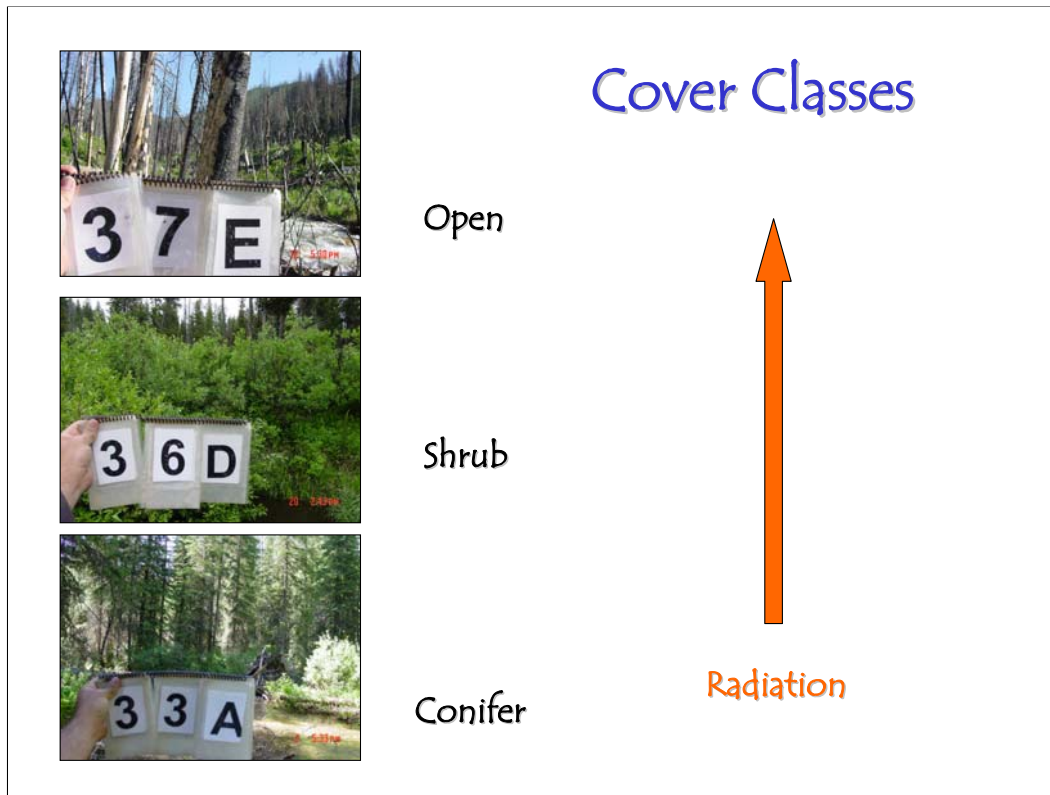
1038



118



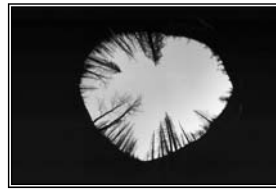
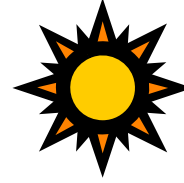
Horizontal photos were collected at each canopy photo location. Sites 31B and 38A represent the sites with the lowest and highest radiation estimates. Radiation values range from 118-1038 megajoules per square meter per year.



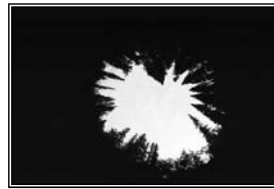
Radiation increased as vegetation cover classes moved from closed canopy conifer to an open structure.

Mean Radiation Per Cover Class

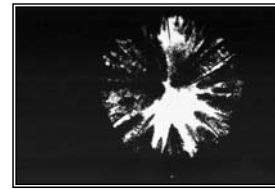
<u>Cover Class</u>	<u>Radiation</u> (MJ/m ² yr)
◊ Open/Barren	786
◊ Broadleaf Shrub	687
◊ Conifer	476



Open



Shrub



Conifer

The canopy photos were binned into three broad vegetation cover classes, open, shrub, and conifer and the mean radiation value was computed for each class.

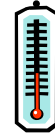
Differences Between Cover Classes

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance	Standard Dev.	
Open	50	39307.41	786.1482	23423.55	151	
Shrub	28	19261.56	687.9129	25274.24	156	
Conifer	103	49046.61	476.1807	28118.68	166	
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3522722	2	1761361	66.73152	2.36701E-22	3.046722
Within Groups	4698264	178	26394.74			
Total	8220986	180				

ANOVA analysis showed that the radiation difference among classes was significant.

What We Know So Far

Mean temperature for 10 streams



Mean radiation for three cover classes

- ◊ Open
- ◊ Shrub
- ◊ Conifer

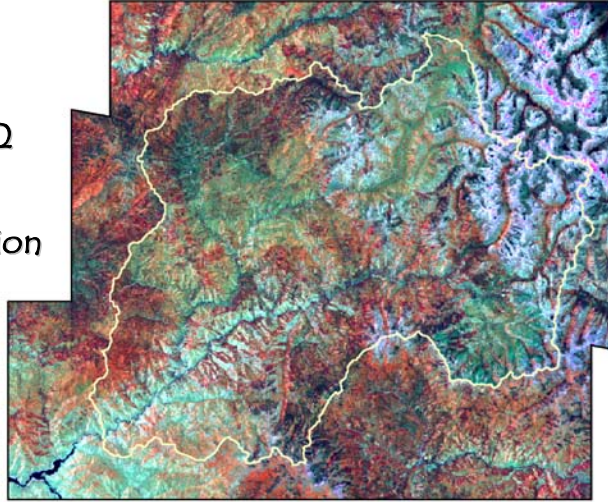


We don't know where these cover classes are on the landscape

At this point, we now have mean temperature measures for 10 streams and mean radiation values for three cover types.

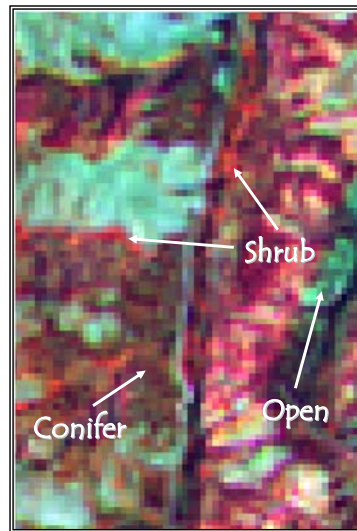
Landsat 7 TM Satellite Imagery

- ◊ Acquired July 10, 2002
- ◊ 30 m spatial resolution
- ◊ Rectified using 2 m DOQ and terrain data
- ◊ Topographic normalization completed

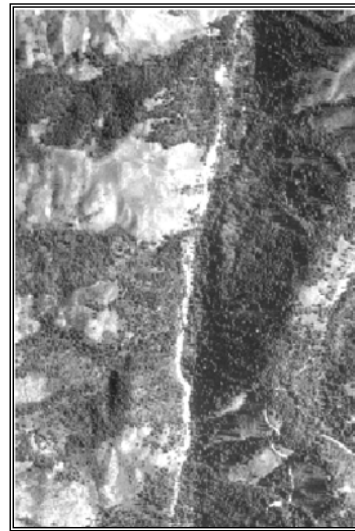


Thematic Mapper satellite imagery was acquired for the purpose of mapping vegetation classes along the stream channel.

Cover Types



TM

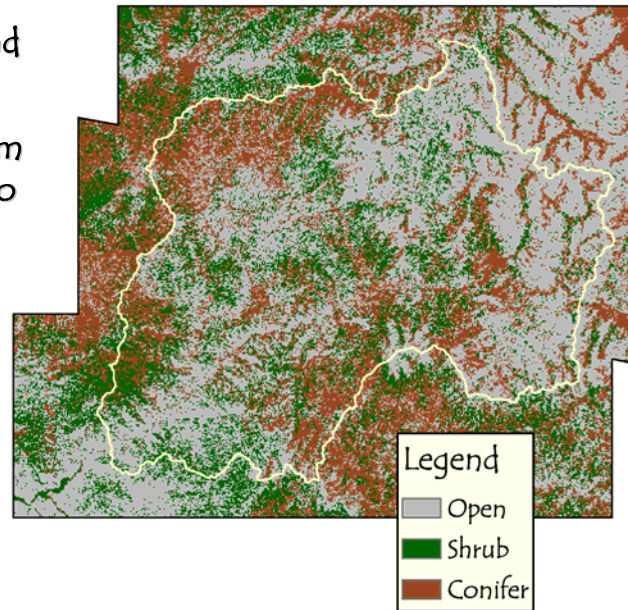


DOQ

The cover types of open, shrub, and conifer were easily identifiable in the satellite imagery.

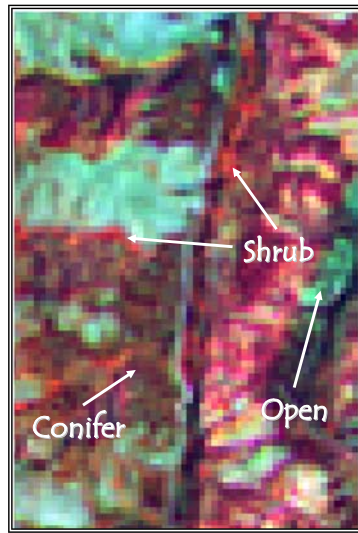
Classification

- ◊ Standard supervised maximum likelihood and unsupervised ISODATA
- ◊ Signatures derived from DOQs and canopy photo sites
- ◊ 55 original supervised signatures

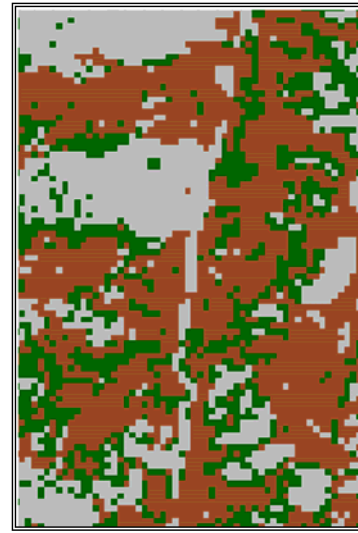


The satellite imagery was classified using standard image classification techniques.

TM and Cover Class Comparison



TM



Classification

The vegetation classification product along side the satellite imagery.

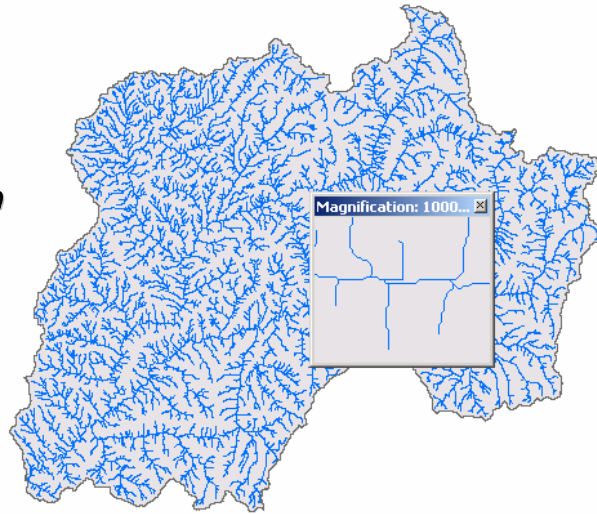
Classification Accuracy

<u>Reference</u>	<u>Classified</u>			<u>Total</u>	
	<u>Open</u>	<u>Shrub</u>	<u>Conifer</u>		
Open	26	4	20	50	52%
Shrub	3	16	9	28	57%
Conifer	2	7	94	103	91%
Total	31	27	123	181	
	84%	59%	76%		75%

The overall accuracy of the satellite derived vegetation classification was about 75%.

TARDEM Stream Lines

Streams derived from
Digital Elevation
Model (DEM)



Stream lines were derived from DEMs using TARDEM software.

TARDEM Streams

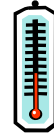
- ◊ Software developed by David Tarboton – Utah State University
- ◊ Streams derived from DEM data
- ◊ Output in ArcInfo coverage format
- ◊ Coverage contains useful stream characteristics attributes
- ◊ TauDEM – ArcGIS plug-in

<http://www.engineering.usu.edu/dtarb/>

TARDEM information.

What We Know Now

Mean temperature for 10 streams



Mean radiation for three cover classes

- ◊ Open
- ◊ Shrub
- ◊ Conifer



Location of cover classes on the landscape



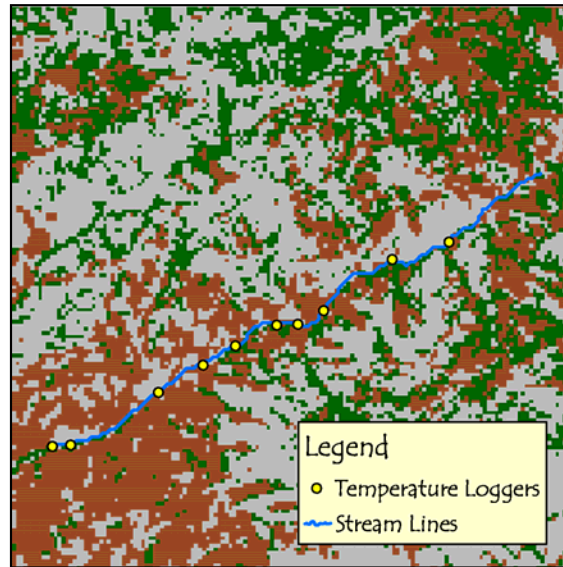
Location of the streams



Summary of the full dataset includes stream temperature data, radiation estimates, vegetation classification, and stream network.

Raster Extraction

- ◊ Use stream lines to extract cover types
- ◊ ArcGIS Spatial Analyst
- ◊ Select a thread of pixels that touch the stream line
- ◊ 1000 m upstream from last logger



Vegetation data was extracted along the stream channel.

Extraction Result

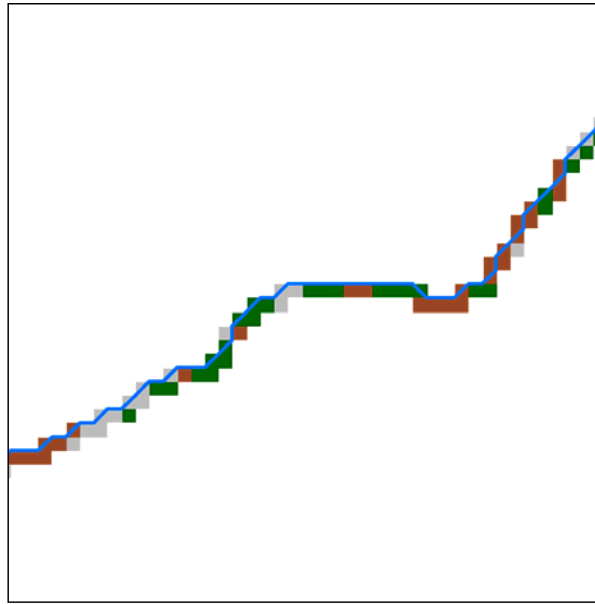
Compute results as a
percentage

Beaver Creek

Open 22%

Shrub 45%

Conifer 33%



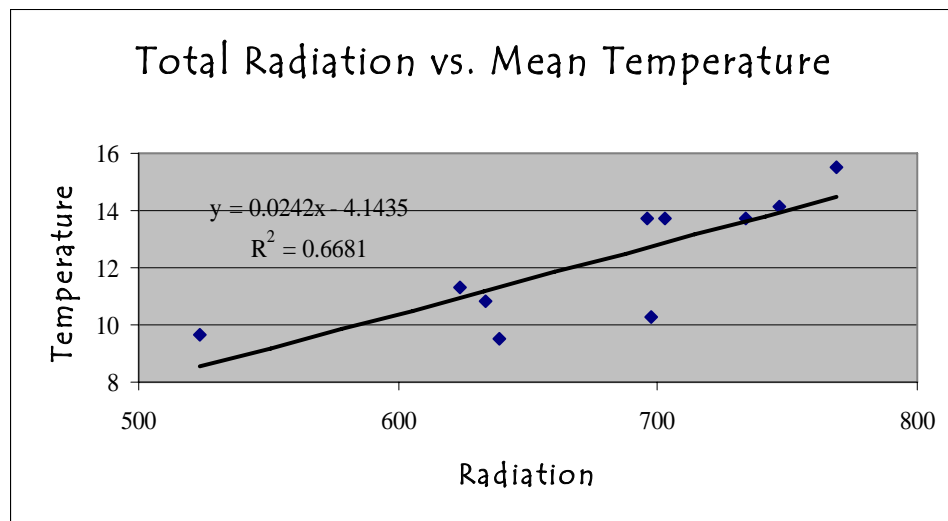
Example of the vegetation extraction along Beaver Creek.

Compute Average Total Radiation Per Stream

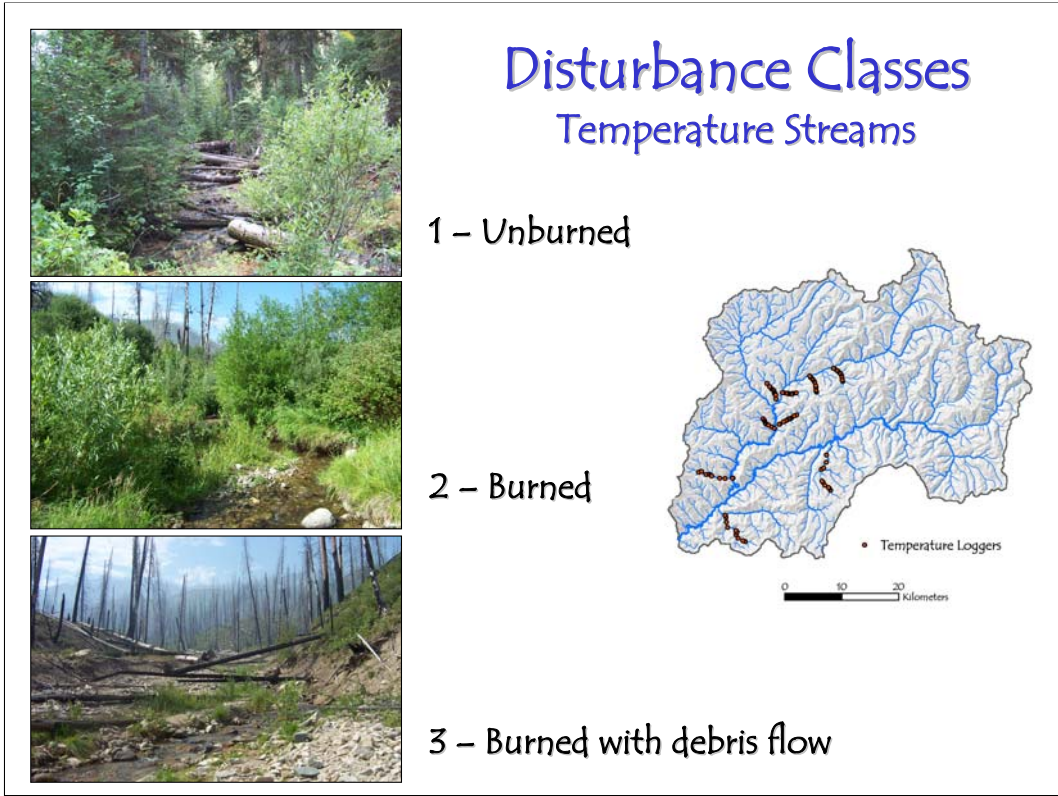
<u>Beaver Creek Cover</u>		<u>Radiation</u>	<u>Total</u>
Open .22	*	786	172.92
Shrub .45	*	687	309.15
Conifer .33	*	476	<u>157.08</u>
			639.15 MJ/m ² yr

The average radiation was computed for each stream with temperature records.

Regression of Radiation and Temperature

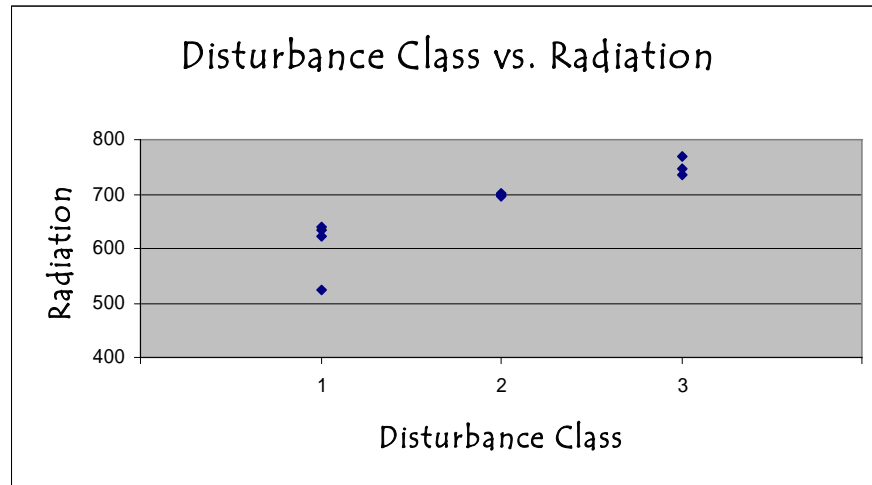


We found a positive relationship between stream temperature and radiation derived from satellite imagery. Each points represents radiation and temperature for each of the 10 streams.



We also looked at radiation values in streams with various types of disturbance.

Disturbance and Radiation

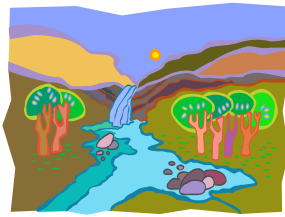


1 – Unburned 2 – Burned 3 – Burned with debris flow

We found that radiation was strongly associated with disturbance class.

Caveats

- ◇ Temperature loggers were within a narrow elevation band, 1000 – 1800 m
- ◇ Accuracy assessment points were not randomly distributed



Initial Conclusions for this Dataset

- ◊ Radiation can be estimated using canopy photography and associated with vegetation types
- ◊ Vegetation can be mapped using satellite imagery at a scale that is appropriate for estimating stream temperature
- ◊ Stream temperature increases with increasing radiation, mapped from satellite imagery
- ◊ Radiation values can be linked to riparian disturbance classes

Acknowledgements

Jason Dunham – Fisheries Research Biologist

Sharon Parkes – Computer Specialist/GIS

Jody Hull – GIS Technician

Iosefa Matagi and Ray Schofield – Field Crew

Thank you