



# RACC

Research on Adaptation  
to Climate Change

## REFERENCE MANUAL FOR HIGH SCHOOL TEAMS 2014-2015

INDEPENDENT





## VT EPSCoR Research on Adaptation to Climate Change (RACC) in the Lake Champlain Basin High School Program 2014-15

### Contact Information:

#### VT EPSCoR Center for Workforce Development and Diversity

Saint Michael's College  
One Winooski Park, Box 137  
Colchester, VT 05439

**Email:** [cwdd@smcvt.edu](mailto:cwdd@smcvt.edu)

**Website:** [www.uvm.edu/~cwdd](http://www.uvm.edu/~cwdd)  
[www.smcvt.edu/academics/epscor](http://www.smcvt.edu/academics/epscor)

**Office:** 251 Founder's Annex, Saint Michael's College

**Lab:** 126 Cheray Science Hall, Saint Michael's College      **Lab Phone:** 802-654-1916

**Lindsay Wieland**, CWDD Director

Phone: 802-654-3272

Email: [lwieland@smcvt.edu](mailto:lwieland@smcvt.edu)

**Katie Chang**, Research Technician

Phone: 802-654-3271

Email: [kchang@smcvt.edu](mailto:kchang@smcvt.edu)

**Kerrie Garvey**, CWDD Project Manager

Phone: 802-654-3270

Email: [kgarvey2@smcvt.edu](mailto:kgarvey2@smcvt.edu)

### Introduction:

Established in 2011, the VT EPSCoR CWDD is one of two centers funded by the National Science Foundation and created through the Research on Adaptation to Climate Change in the Lake Champlain Basin (RACC) award. RACC is focused on understanding the effects of changing climate on the Lake Champlain Basin and to develop adaptive management strategies for the Basin.

**RACC** builds transdisciplinary teams of social and natural scientists to study the Lake Champlain Basin as a coupled human and natural system affected by climate change. We combine collections of data on physical processes, governance, and land use with complex systems modeling. Models will enable scenario testing to help Basin managers and policy makers investigate how adaptive management can be designed and implemented to respond to climate change.

**CWDD** increases the Vermont Science-Technology-Engineering-Math (STEM) workforce in size and diversity through multiple approaches:

- Inspire diverse high school students and undergraduates to enter STEM careers by involving them directly in RACC research. Support the professional development of high school and middle school teachers through involving them in RACC research.

- Match high school teams, undergraduates and middle school teachers with RACC social and natural scientists, who will act as research mentors.
- Target support for girls and underrepresented minorities, veterans, economically disadvantaged high school students, and students with disabilities.
- Involve students from Puerto Rico, New York, Maryland, Texas and other locations outside Vermont to bring a diverse pool of participants into the STEM pipeline.
- Cap off the year with at the VT EPSCoR Student Research Symposium where CWDD participants share research results and network with other STEM professionals.
- Support Native American and First Generation Vermont college students through scholarships to study STEM majors in Vermont.
- Enable the Governor's Institutes of Vermont (GIV) to reach out to every high school in Vermont with scholarships so that girls and economically disadvantaged students can attend the STEM summer institutes and Winter Weekends.
- Work with the Vermont Technology Council to connect undergraduates and small technology businesses that provide students with paid internships.

### **Research on Adaptation to Climate Change in the Lake Champlain Basin (RACC):**

The RACC center is organized around an overarching theme with three research hypothesis driven questions, involving a diversity of scientists and engineers from academia and the private sector that are integrated with public and private stakeholders, undergraduates, middle school teachers, and high school students and teachers. They will study climate change-driven impacts on hydrological processes and nutrient transport in the lake basin (Questions 1 and 2), and develop ecosystem assessment scenarios and models to inform the work of policymakers (Question 3 and Integrated Assessment Model (IAModel)).

Overarching Question: How will the interaction of climate change and land use alter hydrological processes and nutrient transport from the landscape, internal processing and eutrophic state within the lake and what are the implications for adaptive management strategies?

Question 1: What is the relative importance of endogenous in-lake processes (e.g. internal loading, ice cover, hydrodynamics) versus exogenous to-lake processes (e.g. land use change, snow/rain timing, storm frequency and intensity, land management) to lake eutrophication and algal blooms?

Question 2: Which alternative stable states can emerge in the watershed and lake resulting from non-linear dynamics of climate drivers, lake basin processes, social behavior, and policy decisions?

Question 3: In the face of uncertainties about alternate climate change, land use and lake response scenarios, how can adaptive management interventions (e.g. regulation, incentives, treaties) be designed, valued and implemented in the multi-jurisdictional Lake Champlain Basin?

For more information visit: [www.uvm.edu/~epscor](http://www.uvm.edu/~epscor)

## **2014-2015 High School Program:**

The CWDD supports high school teams interested in engaging in RACC research as either Independent Project teams or Streams Project teams. This year will be the sixth year of the VT EPSCoR Streams Project. Each year, the project changes to align with the needs of the overall research program. Independent Project teams work on non-stream related research projects.

Goal: Increase the number and diversity of high school students interested in STEM careers.

### Objectives:

- Students and teachers experience active research;
- Students and teachers develop scientific field and lab knowledge and skills;
- Students make connections with college science faculty, programs, and campuses

### Strategies:

- Train students and teachers in watershed ecology, climate change, systems thinking, and field and lab skills during residential training week.
- Task HS teams with collecting high quality data for the VT EPSCoR research project Research on Adaptation to Climate Change (RACC).
- Convene a Symposium for presentations of RACC research progress, an opportunity for students to experience presenting scientific research, and a venue for students to see where their efforts fit into the overall research program.

# RACC High School Program 2014-2015

## Manual Contents

- Section 1: Team Project
- Section 2: Data Analysis  
and Presentations
- Section 3: Field Safety
- Section 4: Infiltration
- Section 5: Supporting  
Information

### About this manual:

- Become familiar with it at the outset of your participation.
- Use the “Team Project” section of the manual to keep track of your research
- Use this in conjunction with the RACC website ([www.uvm.edu/epscor/highschool](http://www.uvm.edu/epscor/highschool)) which hosts a wealth of additional resources:
  - data analysis tutorials
  - mapping and site information
  - links to useful websites
  - presentation and symposium information

Email [cwdd@smcvt.edu](mailto:cwdd@smcvt.edu) if you need assistance. Your message will be directed to the appropriate staff member.

# High School Team Calendar – Independent Projects 2014-15

<b>June 23-27</b>	<b>Training Week</b>
<b>July – winter</b>	<p>Identify a research question            Collect data / conduct investigation</p> <ul style="list-style-type: none"> <li>➤</li> <li>➤</li> <li>➤</li> <li>➤</li> <li>➤</li> </ul>
<b>December– March</b>	<p><b>Project Presentation</b></p> <ul style="list-style-type: none"> <li>➤ Export data from websites, if needed: <a href="http://www.uvm.edu/epscor/redir/streamsprojectdata">www.uvm.edu/epscor/redir/streamsprojectdata</a> and/or other data sites, if applicable</li> <li>➤ Analyze data</li> <li>➤ Create a poster or PowerPoint presentation describing your research</li> </ul>
<b>February</b>	Submit application for 2015-165 program, if applicable
<b>April, date tbd</b>	Present your research at the 2015 VT EPSCoR Student Research Symposium!

# **Data Analysis and Presentations**

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## Data Analysis Overview

You should begin thinking about your preparing your poster or presentation for the VT EPSCoR Student Research Symposium in April as soon as possible. The basis of your poster or presentation will be an analysis of the data you have gathered during the past year and/or historical data (from the Streams Project online database, or other sources).

The Streams Project has created a **data analysis tutorial** to help guide you through the process of exploring and asking more in-depth analysis questions about your dataset. This should be your primary guide for beginning your data analysis, but the VT EPSCoR CWDD staff members are always available to help you along the way. Some modules are Streams Project –specific, while others are useful to anyone interested in analyzing data.

The tutorials can be found on the website here:

**<http://www.uvm.edu/~epscor/new02/?q=node/1027>**

The first link on the page that says “Complete Tutorial Series - All Modules” will open a PDF with all of the modules compiled into one document. The subsequent links are for accessing modules individually. The following is a list of the individual modules and what they cover:

- Module 1: What is science?
- Module 2: Understanding Streams Project Data
- Module 3: Refining and Retrieving Data
- Module 4: Data Exploration
- Module 5: Statistical Analysis
- Module 6: Summarizing Results and Drawing Conclusions

In this tutorial, statistical analysis is demonstrated using Microsoft Excel. Within each module, look for the “WATCH VIDEO” icon that looks like this:



**These videos help you visualize a number of procedures outlined in the tutorial. \*\*NOTE: To be able to watch the videos, download the QuickTime Player, if it is not already on your computer:**

**<http://www.apple.com/quicktime/download/>**

## **Viewing and Downloading Streams Project Data**

To view or download data in the Streams Project's database, go to the following location website:

**[www.uvm.edu/epscor/redirect/streamsprojectdata](http://www.uvm.edu/epscor/redirect/streamsprojectdata)**

Once you are at the web page:

1. Select the stream sites for which you'd like data. If you'd like data from multiple sites, hold down the "Ctrl" button in between selections. If you'd like data for all the streams sites, select the first stream site, hold down the "Shift" button, and then select the last stream site in the list.
2. Select the report that represents the type of data you are interested in under "Available Reports."
3. Select the date range for which you'd like data.
4. Once you've made these selections click the "Generate Report" button.
5. You can view the data available for these criteria on the webpage that appears. If you click on the heading of a data field in the table, a little box will pop up describing the data contained in that field.
6. To download the data seen here, click the "Export to Excel File" text above the table and save the file on your local computer.

An explanation of the data in the database, and a description of how to download data from this web page can also be found in **Module 3: Refining and Retrieving Data** of the Data Analysis Tutorial. The link to this module can be found here:

**<http://www.uvm.edu/~epscor/new02/?q=node/1027>**

## **Presenting Your Data: VT EPSCoR Student Research Symposium**

All participants of the RACC High School program commit to presenting their research findings at the annual Vermont EPSCoR Student Research Symposium. A symposium is a great way for researchers to present and discuss their work and it provides an important channel for the exchange of information between researchers. At the Vermont EPSCoR Student Research Symposium, participants have the option to choose whether they present their research through a poster or an oral presentation. Both are great ways to share your work!

### **Posters versus Oral Presentations**

Although it can be challenging to present a year's worth of work in 10 minutes, oral presentations can be a rewarding experience because you are the only one front of an audience whose attention you know you have. Oral presentations are brief and consequently the presentation must be clearly and succinctly presented.

Posters are a visual presentation of information that is understandable to the viewer without verbal explanation. Poster presenters have the opportunity to share their work with one person at a time, over an extended period of time. This allows the presenter to describe and discuss their research in greater detail than would be possible in an oral presentation to significantly more people, and allows for dialogue with poster viewers.

## **Posters**

A research or academic poster provides a means of communicating your research at a conference or research symposium. Posters printed by Vermont EPSCoR are 3' x 4' (or 36" x 48"), horizontally or vertically aligned. Upload your final poster file when registering for the symposium by the deadline announced in early March. The CWDD will print and set up your poster at the symposium.

### **How to Create a Poster Using PowerPoint**

For many, this is the first time creating a research poster. Here are some tips for making an informative and attractive research poster:

1. Open PowerPoint
2. Click the 'Design' menu/tab at the top of the screen and select 'Page Setup'
  - i. Change the dimensions of the slide from the default setting to: Width=48, Height=36 (for a horizontal poster), or Width=36, Height=48 (for a vertical poster). This is an important **FIRST** step – if you change the dimensions after putting content on the slide, you will have to re-format all text boxes, graphs, tables, photos, etc.
3. Critical poster elements:
  - i. Title, Author(s) and affiliation(s)
  - ii. Abstract/Summary (*optional*)
  - iii. Introduction/Background: a brief but important overview to secure the viewer's attention
  - iv. Materials and Methods: a brief description of the processes and procedures used, photos (*optional*) should be >300dpi
  - v. Results: outcomes, findings and data displayed through text, tables, graphs, photos, etc.
    - Bulleted lists (rather than paragraphs) may help the reader understand the most important findings
    - Tables, graphs and photos should have captions. Graphs should have a legend, avoid 3-D graphs as they are hard to interpret
  - vi. Discussion/Conclusions: summary or discussion of the significance and relevance of the results, identify possible future research
  - vii. References
  - viii. Acknowledgements
  - ix. Please include the following text somewhere on the poster: Funding provided by NSF Grant EPS-1101317
4. Upload final poster file when registering for the symposium

#### **Tips:**

- A. Use the "Designing Conference Posters" website to get ideas on poster layout and to download poster templates: <http://colinpurrington.com/tips/academic/posterdesign>
- B. Choose a background and text color scheme. No need to go crazy: a white/light poster with black/dark text is often much easier to read than a multi-colored poster. Use cool/muted colors, solid colors, a color gradient, etc.

C. Lettering can make a difference in how easy-to-read your poster is. Here are some suggestions:

- Title: at least 72 pt., bold preferred
- Section Headings: at least 48 pt., bold preferred
- Body Text: at least 24 pt.
- Avoid using all capital letters
- Use sans serif (Arial) for titles & headings
- Use serif (Times New Roman) for body text
- Use bulleted lists where possible instead of paragraphs
- Use *italics* instead of underlining
- White or light colored lettering is hard to read on a dark background when printed. Use black lettering instead on a light colored background

D. Logos: Do not forget to include the logos for the organization(s) that helped make the research possible!

- Funding source: The National Science Foundation's (NSF) logo can be used by recipients of NSF support for the sole purpose of acknowledging that support: <https://www.nsf.gov/policies/logos.jsp>. Please include the following text somewhere on the poster: Funding provided by NSF Grant EPS-1101317
- VT EPSCoR, RACC, CWDD and others if they were important contributors. Logos are available on the "Resources" website: <http://www.uvm.edu/~epscor/new02/?q=node/900>
- Your school logo!

**Example posters from the 2013 VT EPSCoR Student Research Symposium:**

<http://www.uvm.edu/~epscor/new02/?q=node/1285>

## **Oral Presentations**

A research talk provides a means of communicating your research at a conference or research symposium. Oral presentations at the VT EPSCoR Student Research Symposium are limited to 10 minutes: 8 minutes to present your research, 2 minutes for the audience to ask questions.

Presenters often use the general rule of “1 slide per minute”; however the number of slides needed varies based on the complexity of the content of the slides. Upload your final PowerPoint file when registering for the symposium by the deadline announced in early March or bring the file to the symposium on a USB drive. The CWDD will provide the computer, screen, podium, microphone and laser pointer for your use.

### **Oral Presentation Structure (suggested):**

- Title, Author(s), Affiliation (1 slide)
- Outline, *optional* (1 slide): overview of the structure of your talk, some speakers prefer to put this at the bottom of their title slide, audiences like predictability
- Introduction/Background
  - Motivation and problem statement (1-2 slides): Why should anyone care? Most researchers overestimate how much the audience knows about the problem they are addressing.
  - Related Work (0-1 slides)
  - Methods (1 slide): Cover quickly in short talks
- Results (4-6 slides): Present key results and key insights. This is the main body of the talk. Its structure varies greatly as a function of the research conducted. Do not superficially cover all results; cover key result well. Do not just present numbers; interpret them to give insights. Do not put up large tables of numbers as your audience will not have time to take in that much information at once.
- Discussion/Conclusions (1 slide): summary or discussion of the significance and relevance of the results, identify possible future research.
- References
- Acknowledgements
- Please include the following text somewhere on your slides: Funding provided by NSF Grant EPS-1101317

Logos: Do not forget to include the logos for the organization(s) that helped make the research possible!

- Funding source: The National Science Foundation’s (NSF) logo can be used by recipients of NSF support for the sole purpose of acknowledging that support: <https://www.nsf.gov/policies/logos.jsp>. Please include the following text somewhere on your slides: Funding provided by NSF Grant EPS-1101317
- VT EPSCoR, RACC, CWDD and others if they were important contributors. Logos are available on the “Resources” website: <http://www.uvm.edu/~epscor/new02/?q=node/900>
- Your school logo!

**Example posters from the 2013 VT EPSCoR Student Research Symposium:**

<http://www.uvm.edu/~epscor/new02/?q=node/1283>

## **Resources**

**RACC High School Resources:** <http://www.uvm.edu/~epscor/new02/?q=node/900>

- Includes links to datasets available online, including:

### **Data and Data Analysis**

- VT Department of Environmental Conservation Lake Champlain Long Term Monitoring
  - VT Department of Environmental Conservation Volunteer Monitoring
  - USGS Stream Gauge Data
  - Vermont Water Quality Data
  - NOAA Quality Controlled Local Climatological Data
  - VT EPSCoR Data Analysis Tutorials
  - Data Analysis in Excel
- 
- Helpful hints on posters and oral presentations
  - High resolution logos to include on your poster, etc.

**Data Webinar video** by Dr. Declan McCabe:

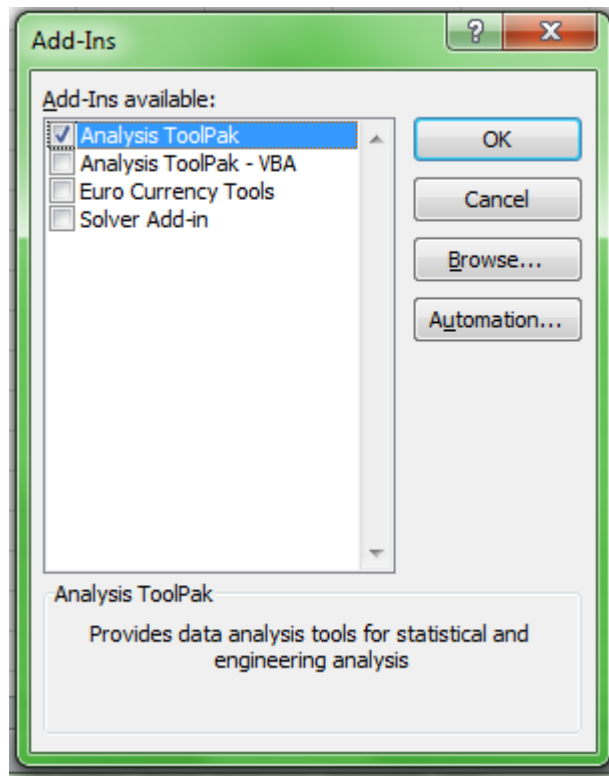
<http://www.uvm.edu/~epscor/new02/?q=node/1237>

- Walks you through how to find different data sources online, how to groom and present your data using Excel, and how to use PowerPoint to create a presentation

## *Data analysis*

### **Data analysis in Excel using Windows 7/Office 2010**

- Open the “Data” tab in Excel
- If “Data Analysis” is not visible along the top toolbar then do the following:
  - Right click anywhere on the toolbar and select “Customize quick access toolbar...”
  - On the left click on “Add-Ins”
  - Near the bottom, use the pull-down menu and select “Excel Add-Ins” and click “Go” to bring up this menu:



- 
- Select the “Analysis ToolPak” and click “OK”.



## Using one-way ANOVA in MS Excel

**Introduction:** When your observations fall into two or more categories of continuous or even discrete variables, you may be interested in asking if the groups differ from each other. Is fish diversity higher in phosphorus-enriched ponds than in low-phosphorus ponds? Does the abundance of forest-floor plants differ between clear-cut, tornado-damaged, and control plots of forest? Questions of this nature are answered using analysis of variance (ANOVA). It is worth mentioning that in the case of 2 categories you can run a *t* test or an ANOVA and the result will be the same.

### Analysis:

1. Organize your comparative data in adjacent columns (Table 1). There is no need to average them for analysis, and in fact averages will be calculated automatically during the ANOVA or *t* test.
2. From the “Data” tab, select “data analysis” (this must be added from the “addin” menu; see previous section).
3. Choose “ANOVA single factor”; click OK. Table 1 lists data from three habitats; so the *factor* of interest is habitat.
4. Click the tiny red arrow by “input range” and highlight all of the data including the column headings. Click the “Columns” button and check the “Labels in first row” box.
5. Select any of the output options that you like and hit “OK”
6. The output from the fake data should look like this:

Number of mammal species		
island	mainland	peninsula
2	5	3
3	4	2
3	6	4
5	5	3
1	4	3
2	4	2

Table 1. Fake data for ANOVA

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
island	6	16	2.666667	1.866667		
mainland	6	28	4.666667	0.666667		
peninsula	6	17	2.833333	0.566667		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	14.77778	2	7.388889	7.150538	0.006593	3.68232
Within Groups	15.5	15	1.033333			
Total	30.27778	17				

7. The conclusion based on the *p-value* would be that number of species differ significantly among the three habitats. Note that the ANOVA does not tell you which groups are different, although in this case it looks like more species are found on the mainland and there is no difference between the island and the peninsula.
8. Finally, if you are making a comparison between just 2 groups, you can use exactly the same procedure. Or you could choose to run a *t*-test and it will give you a result that is mathematically identical to that produced by an ANOVA run on 2 groups. We could go back to the fake data and ask if the island and peninsula differ from each other by running the test without including the mainland data column.

**Graphing ANOVA-type data:** Use the averages to draw a bar graph. Add standard error bars to the graph. Calculate those using this formula:  $=stdev(A1:A6)/Sqrt(6)$  (assuming your data are in cells A1 through A6 and you have 6 data points). More detailed instructions are provided in the graphing section of this manual.

## Regression in MS Excel

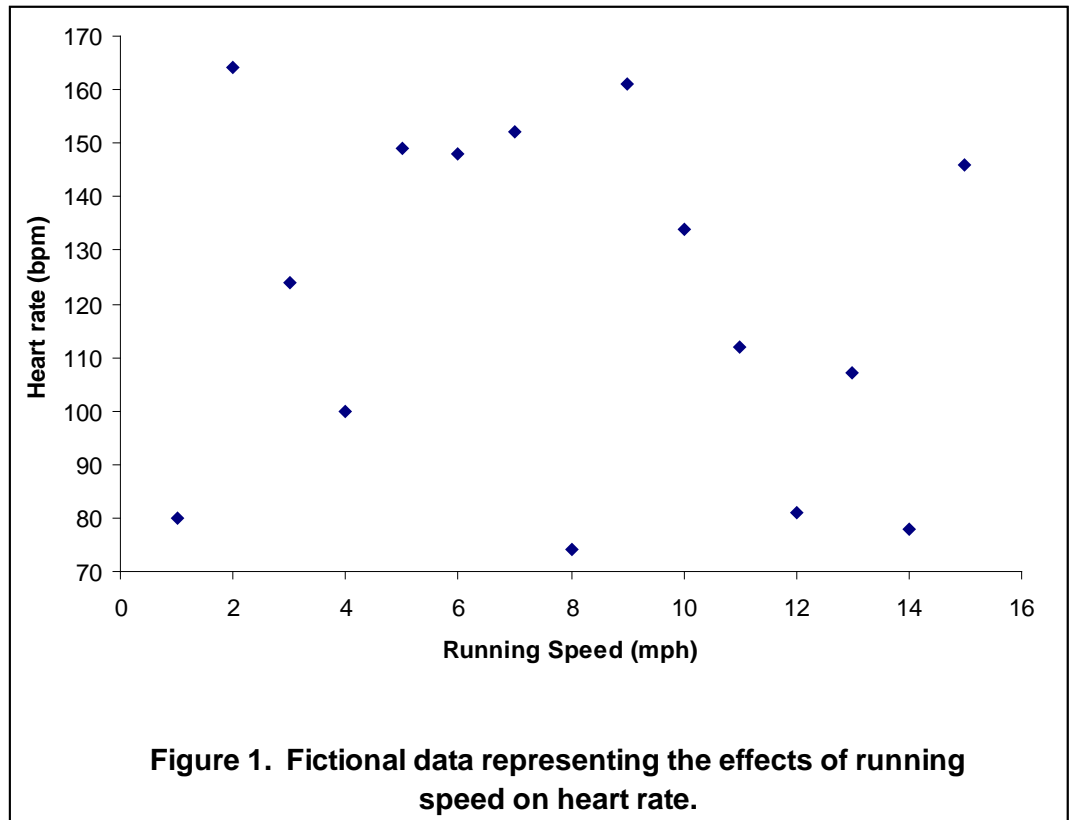
Does blood pressure increase with age? Does shrub cover decrease with increasing canopy cover? Is there a relationship between phosphorus concentration and algal cell density in ponds? All of these questions can be addressed using regression.

### Nature of the data

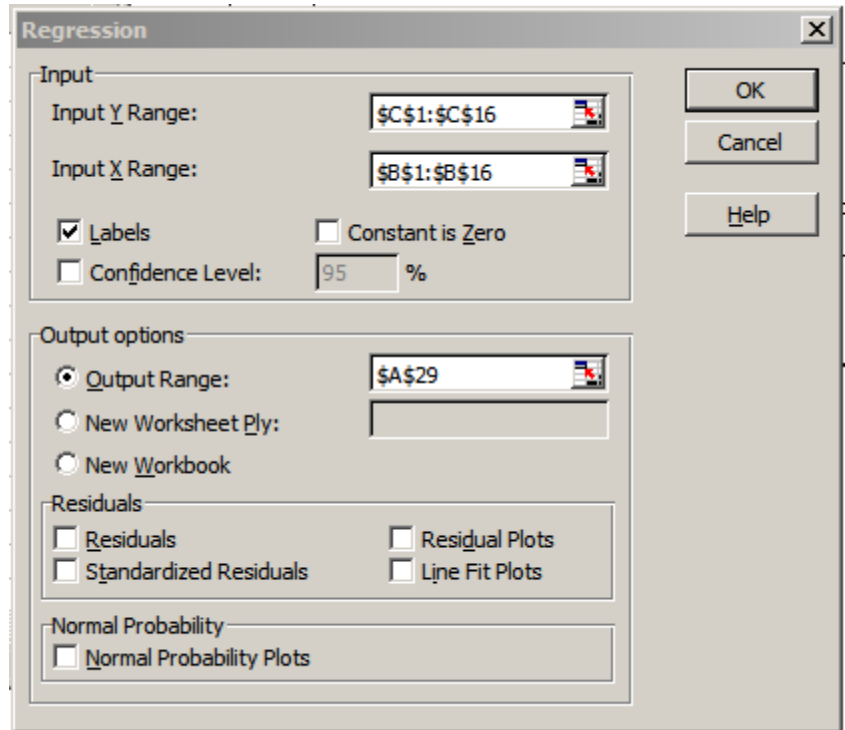
All of the datasets described above are *continuous*; that is to say, they vary over some range without breaks. They are not *categorical* (like male and female), that are not *discrete* (like number of people in a single car; you would not typically think about 3.5 people in a car). As the range of a discrete variable increases (number of plants per hectare for example), the larger number means that what in fact is a discrete variable can be treated as continuous.

### Graphing

We typically graph such datasets using a scatter plot (Figure 1). If we have a basis for considering for example that running speed impacts heart rate, then we would use running speed on the horizontal ( $x$ ) axis, and heart rate on the vertical ( $y$ ) axis. In this case running speed is the *independent variable*. The *dependent, or response variable* is heart rate because we expect it to *depend on, or respond to* running speed.



**Analysis:** We might look at the pattern on the right and perceive a pattern, or not! As is the case with all statistics, the point is to remove subjectivity and have firm criteria for claiming a relationship. The analysis one would use for this sort of question is *regression*. There are many forms of regression for relationships of different shapes, but for our purposes we are considering only *linear regression*. In other words we are asking only if, and how well a straight line can describe the relationship between variables. In excel under the *Data tab*, select *data analysis, regression* to bring up this window:



The response variable goes in the Input Y Range and the independent variable goes in the Input X range. You can click on the tiny red arrow in each case and highlight the appropriate portion of the data (including labels). The output range simply is a place for the statistical output to go.

**Output:** Output from the preceding data set:

SUMMARY OUTPUT								
<i>Regression Statistics</i>								
Multiple R	0.169583375							
R Square	0.028758521							
Adjusted R	-0.045952362							
Standard E	33.23140781							
Observatio	15							
<i>ANOVA</i>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	425.0892857	425.0893	0.384931	0.545699			
Residual	13	14356.24405	1104.326					
Total	14	14781.33333						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	130.5238095	18.05655676	7.22861	6.66E-06	91.51499	169.5326	91.51499	169.5326
Running S	-1.232142857	1.985956467	-0.62043	0.545699	-5.52254	3.058255	-5.52254	3.058255

The number under *Significance F* is the *p* value. In this case the *p* value is greater than 0.05 and we can conclude that there is no relationship between running speed and heart rate.

**Regression example 2:** Along with other questions, Connon and Simberloff's (1978) paper examined the effect of sampling bias on collection data. They concluded that the number of collecting trips explained more of the variability in number of plant species observed on Galapagos Islands than did Island size or any other island feature measured. The data set:

Species	Collecting
57	10
31	6
3	1
25	4
2	1
18	6
10	6
8	1
2	1
96	13
94	12
40	7
5	2
54	13
346	27
47	7
2	1
102	10
108	9
12	6
69	10
290	28
237	24
440	38
61	11
283	29
45	6
16	3
21	5

And the statistical output:

SUMMARY OUTPUT								
<b>Regression Statistics</b>								
Multiple R	0.973547							
R Square	0.947795							
Adjusted R	0.945861							
Standard Error	27.01902							
Observations	29							
<b>ANOVA</b>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	357850.2	357850.2	490.1875	7.62E-19			
Residual	27	19710.73	730.0272					
Total	28	377561						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-31.902	7.35061	-4.34005	0.000179	-46.9842	-16.8198	-46.9842	-16.8198
Collecting	11.61333	0.524536	22.14018	7.62E-19	10.53707	12.68959	10.53707	12.68959

Output	Value	Standard interpretation
p value	7.2 E-19	There is a very significant relationship between number of trips and number of species observed
Coefficient (of collecting trips)	11.61	The slope is positive telling us that as number trips increases, so does number of species seen. Negative slopes indicate the opposite trend.
R square	0.947	This measures how tight or strong the relationship is. In this case we can say that collecting trips explain 94.7% of the variability in number of species observed.

**Graphing example 2:** Connor and Simberloff's (1978) data set is presented graphically in the manual section on graphing. Compare how the data follow a tight linear pattern compared to the fake data on heart rate in this section.

## Graphing

### Figures in Community Ecology

All graphs, maps, photographs, and sketches are considered “Figures” and appear in a numbered sequence in the order cited in your paper. Any set of numbers and/or letters is considered a table and tables have their own numbered sequence (IE, even after three figures, your first table is still *Table 1*).

A good graph minimizes clutter and unnecessary ‘ink’. Use the MS Excel “Scatter Plot” option to make graphs displaying continuous data on the vertical and horizontal axis. The species area data for the upcoming lab report are a good example; area on the X axis; number of species on the Y axis. **Remove** all of the following items added by Microsoft excel: “Series 1”; background color; frames on right and top; grid lines; 3D effects.

### Scatter plots

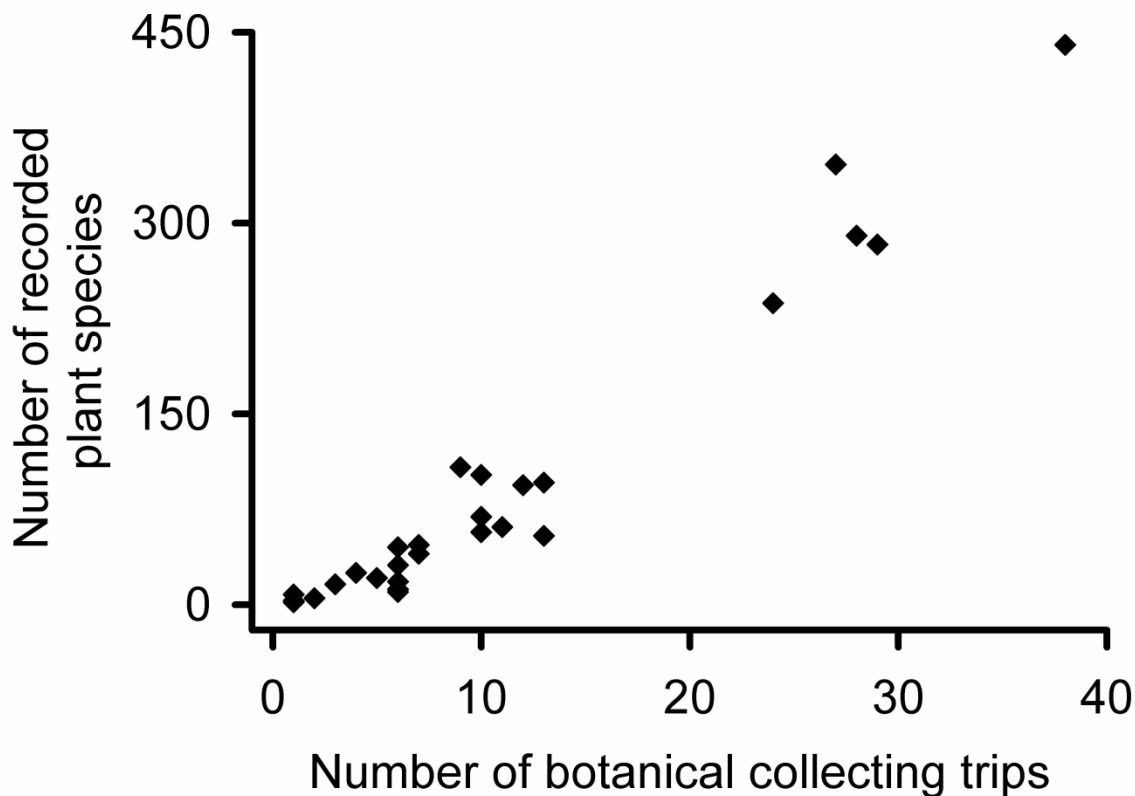


Figure 1. Illustrating the point that more sampling leads to more species observed. Connor & Simberloff (1978) analyzed data from collecting trips to the Galapagos Islands and found that number of collecting trips better explained number of species recorded than did island area, elevation, or isolation. Data extracted from Table 3 in Connor & Simberloff (1978).

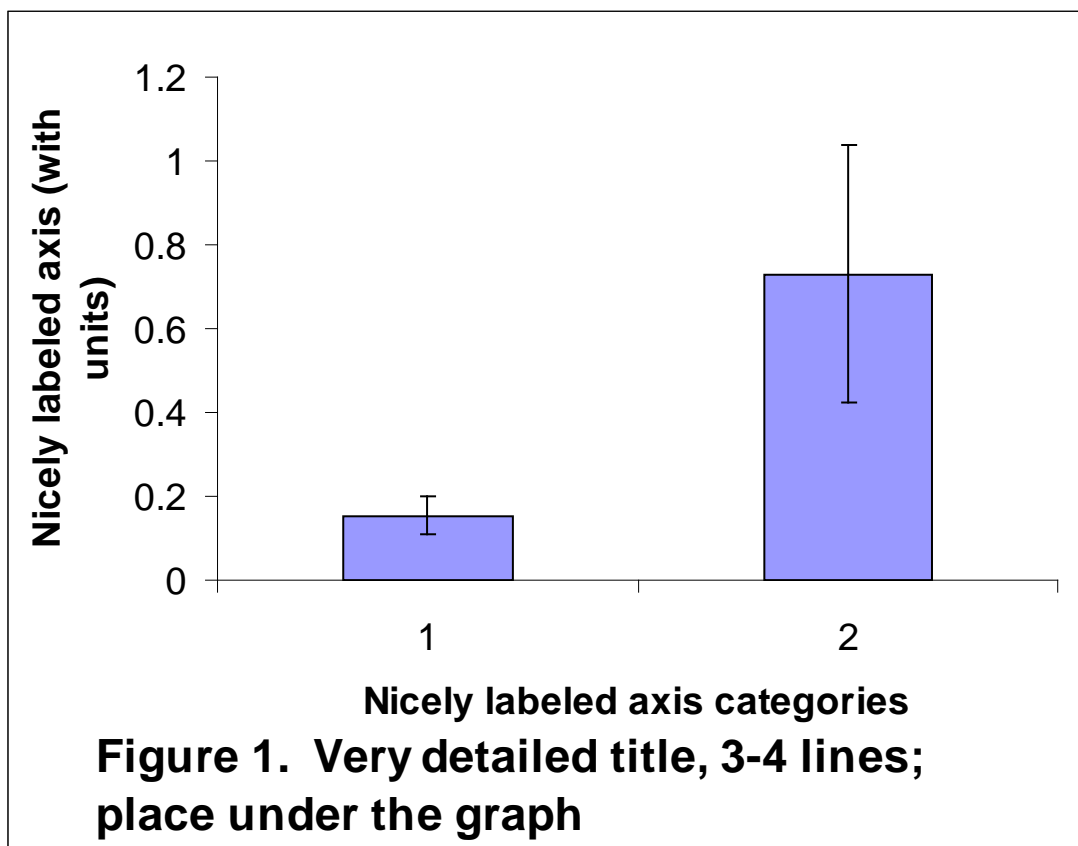
The figure legend is always placed underneath and contains roughly a paragraph of information describing the figure content in sufficient detail that the figure stands alone. The

*legend* inserted by MS excel is useful *only if two or more data sets are displayed* on one graph using symbols.

This figure contains data that span the nearly entire range presented. If we were presenting data from only the largest five islands we would adjust the horizontal axis to run from 20 to 40, and the vertical axis from 150 to 450. Note that the axis lines have been thickened and fonts enlarged beyond the default. **Important:** Graphs should not start at zero, zero if the data range fall between 75 and 85 (for example).

## Bar graphs

We use bar graphs when presenting the averages of *continuous* variables (on the Y axis) from one or more *categories* on the horizontal axis.



The bar height equals the average of the response variables for treatments 1, and treatments 2. The error bars above and below the average in this case equal standard error; calculate these values as:  $(\text{standard deviation})/(\text{square root of the number of samples})$ . The scale is appropriate to the data; if the averages were 150 and 200, I might start the axis at 100 rather than zero. **Important:** You should replace the numbers on the horizontal axis with names of sites or treatments (see example under adding error bars handout).

## Adding error bars to bar graphs in excel

**Introduction:** Bar graphs are among the most common ways to present the averages of a set of treatments or conditions in community ecology and many other fields. Every average is based on raw data measured from a sample of several individuals. If I care about grass density in my lawn I might count the number of stems from several small quadrats and then calculate the average number of stems. The numbers of stems in each of my individual quadrats will be greater than or less than the average. In other words *there is variability in the raw data*. We might expect more variability in the heights of people than in the heights of Volkswagens. *Some data sets are more variable than others*. We use error bars above and below the average to depict that variability

**How to measure variability:** There are several metrics used to express variability. Standard deviation expresses the *variability in your sample* and is calculated in MS Excel using this Formula 1.

$$= stdev(A1:A6).....Formula 1$$

The formula calculates the standard deviation from the raw data you entered in the cells A1 through A6 in the spreadsheet. You can refer to any set of cells in the spreadsheet by changing the letters and numbers in parentheses in Formula 1. The disadvantage of standard deviation is that it increases in magnitude as your sample size decreases. Samples can be expensive or time consuming to collect and so we often need to work with small sample sizes. What we really need is a measure of variability in the entire population, and not just in our sample.

Standard error adjusts the value of standard deviation based upon the sample size using Formula 2

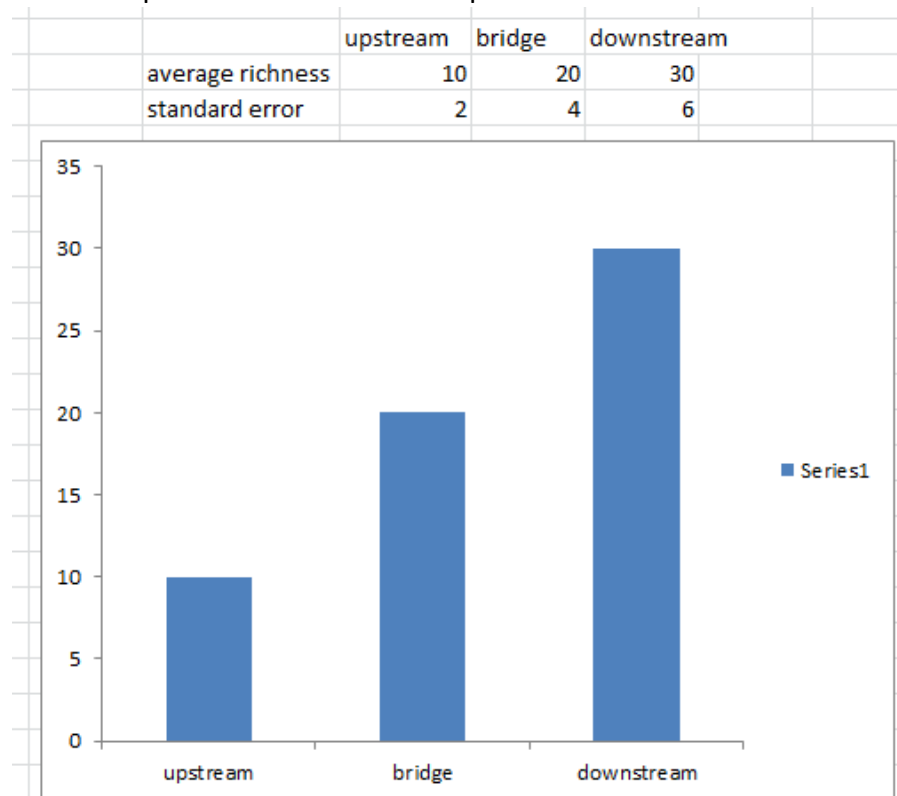
$$= stdev(A1:A6)/sqrt(n).....Formula 1$$

Where  $n$  = the number of replicates in your sample; don't enter the letter  $n$ , enter the number of samples you took or refer to a cell in the spreadsheet that contains that information. *Sqrt* calculates the square root of whatever value you use to replace  $n$  in Formula 2. **Standard error will be the preferred measure of variability used throughout this course.**



### How to add the error bars to your bar graph:

Lay your data out as illustrated below. In this case the fake data represent the average number of insect species found several samples taken from each of three locations in a stream.



Note:

- Standard error values are underneath the graphed averages.
  - The graph has been moved in the spreadsheet so as not to hide the numerical values.
1. Click anywhere on the chart - this will reveal the "Chart Tools" at the top of the window. Click "Layout"
  2. Right click on any bar in the graph – 2 small windows will pop up – work in the smaller upper one. Click the little drop down arrow and select the data set to which you'd like to add error bars (*Series 1* unless you have renamed the data set).
  3. Now, go up to "Chart Tools" at the top and select "Error Bars" / "More error Bar Options" (because all of the other options offered are, to be perfectly honest, fake).

4. Click "Custom" and "Specify Value".

The screenshot shows an Excel spreadsheet with a bar chart. The spreadsheet has columns labeled 'F', 'G', and 'H', and rows labeled 'pstream', 'bridge', and 'downstream'. The data values are: 'pstream' (10, 20, 30), 'bridge' (2, 4, 6). The bar chart shows two bars: 'bridge' and 'downstream'. The 'Format Error Bars' dialog box is open, showing options for 'Vertical Error Bars' such as 'Line Color', 'Line Style', 'Shadow', and 'Glow and Soft Edges'. The 'Display' section is set to 'Both' for 'Direction' and 'Cap' for 'End Style'. The 'Error Amount' section is set to 'Custom' with a 'Specify Value' button. The 'Custom Error Bars' dialog box is also open, showing 'Positive Error Value' and 'Negative Error Value' both set to '= {1}'.

5. Next click the tiny red arrow in the box under "Positive Error Bar"; highlight the values for the standard errors that are lined up under the averages. Hit "Enter"!
6. Now, you would think that having selected "both", that both the upper and lower error bars would be displayed; you would be wrong! Repeat the process for "Negative Error Bars".
7. Click "Close".
8. Truly beautiful error bars will now grace your bar graph!

# **Field Safety**

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## **First Aid Kit**

When working in the field, it is important to be prepared for emergencies. Although you will not be traveling far from your car when you visit your field sites for the VT Streams Project, accidents may still happen. Therefore, a well-stocked first aid kit is an important thing to have. Carry a first aid kit with you to your site or keep one in the car. You may purchase a pre-made kit at the store, or you may make your own using the recommended list of items below as a reference. Whichever you chose, it is important to include any personal items such as medications and emergency phone numbers. Check the kit regularly and replace any used or out-of-date items.

- Adhesive bandages (assorted sizes)
- Antibiotic ointment
- Antiseptic wipes
- Instant cold compress
- Hydrocortisone ointment
- Scissors
- Sterile gauze pads (assorted sizes)
- Butterfly bandages
- Tweezers
- Prescription medications (asthma inhalers, EpiPen)
- Emergency phone numbers
- Charged cell phone

## Didymo Fact Sheet



*Didymosphenia geminata*, commonly known as “Rock Snot” or “Didymo,” is an aggressive freshwater alga that has undergone a recent large expansion in range. It has the potential to form nuisance blooms during which it can form mats several inches thick by attaching itself to streambeds by stalks that form a thick brown mat on rocks, plants, and other aquatic surfaces. The thick growth reduces the quantity and quality of aquatic habitat.

Didymo was detected in rivers of Vermont, New York, and New Hampshire during the summers of 2006 and 2007. Because the factors that cause Didymo to undergo rapid growth are unknown and there is no known method of eradication, it is important to prevent the spread of these algae to uninhabited streams. Therefore, ***we disinfect all waders and equipment when traveling between streams.*** In order to prevent the spread of didymo to other regions waders should not be transported and used in different regions or countries.

Follow the link for a detailed description of Didymo by the Vermont Department of Environment Conservation Water Quality Division:

[http://www.anr.state.vt.us/dec//waterq/lakes/htm/ans/lp\\_didymo.htm#how\\_can\\_I\\_disinfect](http://www.anr.state.vt.us/dec//waterq/lakes/htm/ans/lp_didymo.htm#how_can_I_disinfect)

## **Disinfecting Waders**

We have supplied your team with concentrated Quaternary Ammonium Disinfectant (Quat solution) to kill and prevent the spread of nuisance biological agents such as Didymo. This procedure is adapted from the Vermont Agency of Natural Resources method for equipment disinfection.

**\*\*ATTENTION: Quat is a highly basic solution. Protective gloves MUST be worn when handling the concentrated solution. Once diluted with water, it is safe to handle\*\***

To prepare a 2.5% solution:

- Add 25mL of concentrated Quat to a spray bottle. Dilute to 1L. (For 500mL of solution, add 12.5mL of concentrated Quat and dilute with water to 500mL.) **Quat solutions should be replaced every 2 – 3 days to remain effective, so prepare only as much as is necessary for a site visit.**
- Fill the second spray bottle with water.
- When exiting the stream following sampling, spray waders and other equipment thoroughly with the 2.5% Quat solution. Let sit for ~2 minutes. Spray with the water to rinse.

## Field Precautions

### Poison Parsnip



- **Location:** Predominately found on the sides of highways and fields throughout Vermont.
- **Appearance:** The plants typically grow 3-6 feet tall and resemble Queen Anne's Lace, but the flowers are yellow instead of white.
- **Danger:**
  - The plant contains a high concentration of furocoumarin chemicals
  - The plant's juices may be transferred to your skin if you brush against the flower tops or broken leaves or stems
  - When the juices on the skin are exposed to ultraviolet light on both sunny and cloudy days the furocoumarin chemicals bind with nuclear DNA and cell membranes.
  - **This process destroys cells and skin tissue, causing severe burns in which the skin to redden and blisters**
- **Protecting Yourself:**
  - Avoid exposure to the plant by choosing stream sites or access areas free from poison parsnip
  - If unavoidable, wear long sleeve shirts, pants (or your waders!), and gloves to prevent direct contact with your skin
  - Rinse and wash all clothing items and skin surfaces immediately following possible exposure. Keep exposed skin out of sunlight.



## Poison Ivy



Poison ivy in spring.

Image © Jonathan Sachs 2002

**Myths Vs Facts:** Fact #1: this fact list is modified from [www.zanfel.com](http://www.zanfel.com)

**Myth: Scratching poison ivy blisters will spread the rash.**

**Fact:** Fluids from blisters will not spread the rash. Before blisters form, the rash can only be spread by unbound urushiol. Scratching of blisters can cause bacterial infection.

**Myth: Poison ivy rash is "contagious."**

**Fact:** The rash is a reaction to urushiol. The rash cannot pass from person to person after the urushiol binds to skin.

**Myth: After the first time, I can't get poison ivy again.**

**Fact:** Not everyone reacts to poison ivy upon first or subsequent exposures, people generally become more sensitized with each contact and may react more severely to subsequent exposures.

**Myth: Once allergic, always allergic to poison ivy.**

**Fact:** A person's sensitivity changes over time, even from season to season. People who were sensitive to poison ivy as children may not be allergic as adults.

**Myth: Dead poison ivy plants are no longer toxic.**

**Fact:** Urushiol remains active for up to five years. Never handle dead plants that look like poison ivy without proper protection.

**Myth: Burning is the best way to dispose of poison ivy.**

**Fact:** The toxic oils from poison ivy spread in the smoke and can cause full-body rash and more serious health problems if inhaled. Zanfel Laboratories provides poison ivy treatment brochures for free to BSA troops. Call 1800 401 4002

# Avoid poison ivy

## Preventing contact with poison ivy

- Do not touch or handle any part of the plant
- Remove and wash shoes or clothing that has contacted poison ivy. Wash your hands immediately with soap and water

## Preventative treatment

 Modified From <http://poisoncontrol.uchc.edu>

- If you have touched poison ivy, avoid spreading the oils to other body parts and wash the affected skin with soap and water within 15 minutes
- Use a nail brush to clean under finger nails
- Swab with rubbing alcohol after washing



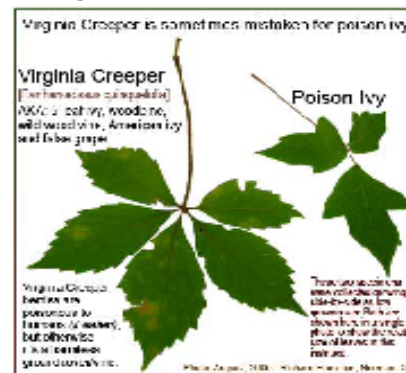
Poison ivy in summer.

[www.kentuckycrosswords.com](http://www.kentuckycrosswords.com)

## If a rash develops

 From <http://poisoncontrol.uchc.edu>

- Apply calamine lotion, cool compresses, or over the counter corticosteroid creams to lessen itching. Oatmeal baths can also help. Avoid scratching and cover open blisters to avoid infection. If face or genitals are involved, see a doctor for evaluation. If symptoms are persistent after these treatments see a doctor.



## Leaf size varies greatly.



# Ticks & Lyme Disease

## T I C K S & L Y M E D I S E A S E

### What Is Lyme Disease?

Lyme disease is a bacterial infection caused by the bite of an infected deer tick. Untreated, the disease can cause a number of health problems. Patients treated with antibiotics in the early stage of the infection usually recover rapidly and completely.

### Where Is Lyme Disease Found?

In the United States, infected ticks can be found in the north-east, including New York State; in the upper Midwest; and along the northwest coast.

### What Are the Symptoms of Lyme Disease?

The early symptoms of Lyme disease may be mild and easily missed. If you find a tick attached to your skin, remove the tick with tweezers and watch for the symptoms of Lyme disease. In 60-80% of cases the first symptom is a rash, known as *erythema migrans*, that:

- Occurs at or near the site of the tick bite.
- Is a “bulls-eye” circular patch or solid red patch that grows larger.
- Appears between three days and one month after the tick bite.
- Has a diameter of two to six inches.
- Lasts for about three to five weeks.
- May or may not be warm to the touch.
- Is usually not painful or itchy.
- Sometimes multiple rashes appear.

### How Can I Safely Remove a Tick?

If you DO find a tick attached to your skin, do not panic. Not all ticks are infected, and your risk of Lyme disease is greatly reduced if the tick is removed within the first 36 hours.

#### To remove a tick:

- Use a pair of pointed tweezers to grasp the tick by the head or mouth parts right where they enter the skin. DO NOT grasp the tick by the body.
- Pull firmly and steadily outward. DO NOT jerk or twist the tick.
- Place the tick in a small container of rubbing alcohol to kill it.
- Clean the bite wound with rubbing alcohol or hydrogen peroxide.
- Monitor the site of the bite for the next 30 days, for the appearance of a rash. If you develop a rash or flu-like symptoms, contact your health care provider immediately.

### What Else Can Be Done?

- Keep lawns mowed and edges trimmed.
- Clear brush, leaf litter and tall grass around the house, and at the edges of gardens and stone walls.
- Stack woodpiles neatly away from the house and preferably off the ground.
- Clear all leaf litter (including the remains of perennials) out of the garden in the fall.
- Keep the ground under bird feeders clean so as not to attract small animals.
- Locate children’s swing sets and other play equipment in sunny, dry areas of the yard, away from the woods.

*For more information on Lyme disease, contact your local health department or refer to the NYS Department of Health web site at [www.health.state.ny.us](http://www.health.state.ny.us)*



- Do NOT apply repellents directly to children. Apply to your own hands and then put it on the child.
- When applying repellents, avoid the child's face and hands.
- Do not apply repellents on skin damaged by sunburn, cuts, bruises or other conditions, such as psoriasis.
- Avoid prolonged and excessive use of DEET.
- Do NOT apply repellents in enclosed areas.
- Do NOT apply directly on your face.
- Do NOT apply near eyes, nose or mouth.
- Wash treated skin and clothing after returning indoors.
- If you believe you or a child is having an adverse reaction to a repellent containing DEET, wash the treated area immediately and contact your local health care provider or local poison control center.

**Also consider these important facts:**

- If you tuck pants into socks and shirts into pants, be aware that ticks will climb upward to hidden areas of the head and neck, so spot-check clothes frequently.
- Clothes can be sprayed with DEET or treated with permethrin. Follow label instructions carefully.
- Upon returning home, clothes can be put in a high temperature dryer for 20 minutes to kill any unseen ticks. A shower and shampoo may help to dislodge crawling ticks, but this is not always effective.
- Any contact with vegetation, even playing in the yard, can result in exposure to ticks. Frequent tick checks should be followed by a whole-body examination and tick removal each night. This is the single most effective method for prevention of Lyme disease.

Ticks will attach themselves anywhere including the thighs, groin, trunk, armpits and behind the ears. If you are infected, the rash may be found in one of these areas.



Around the time the rash appears, other symptoms, such as joint pain, chills, fever and fatigue can occur, but they may seem too mild to require medical attention. As Lyme disease progresses, severe fatigue, a stiff aching neck, and tingling or numbness in the arms and legs, or facial paralysis can occur.

The most severe symptoms of Lyme disease may not appear until weeks, months or years after the tick bite. These can include severe headaches, painful arthritis, swelling of the joints, and heart and central nervous system problems.

**How Is Lyme Disease Diagnosed?**



If you think you have Lyme disease, you should see your health care provider immediately. Early diagnosis of Lyme disease should be made on the basis of symptoms and history of possible exposure to ticks. Blood tests may give false negative results if performed in the first month after the tick bite.

**How Is Lyme Disease Treated?**

Early treatment of Lyme disease involves antibiotics and almost always results in a full cure. However, the chances of a complete cure decrease if treatment is delayed.

In a small number of cases, Lyme disease can become a chronic condition. However, some patients have reported slow improvement and even an end to symptoms, months or even years after treatment.

### How Can I Protect Against Ticks and Prevent Lyme Disease?

Deer ticks live in shady, moist areas at ground level. They will cling to tall grass, brush and shrubs, usually no more than 18-24 inches off the ground. They also live in lawns and gardens, especially at the edges of woods and around old stone walls.

Deer ticks cannot jump or fly, and do not drop onto passing people or animals. They get on humans and animals only by direct contact. Once a tick gets on the skin, it generally climbs upward until it reaches a protected area.

In tick-infested areas, your best protection is to avoid contact with soil, leaf litter and vegetation. However, if you garden, hike, camp, hunt, work, or otherwise spend time in the outdoors, you can still protect yourself:

- **Wear light-colored clothing** with a tight weave to spot ticks easily.
- **Wear endosed shoes, long pants and a long-sleeved shirt.** Tuck pant legs into socks or boots and shirt into pants.
- **Check clothes and any exposed skin frequently** for ticks while outdoors.
- **Consider using insect repellent.**
- **Stay on cleared, well-traveled trails. Avoid contacting vegetation.**
- **Avoid sitting directly on the ground or on stone walls.**
- **Keep long hair tied back,** especially when gardening.
- **Do a final, full-body tick check at the end of the day** (also check children and pets), and remove ticks promptly.

### What Do Ticks Look Like?

Two common types of ticks are dog ticks and deer ticks. Deer ticks can carry Lyme disease. Dog ticks can carry Rocky Mountain spotted fever but have not been known to carry Lyme disease.



Deer Ticks Actual Size



Adult Dog Tick Actual Size



Enlarged View Female Deer Tick



Enlarged View, Male and Female Dog Ticks

**Female deer ticks** have four pairs of legs and are red and black in color, while the male is all black. Young deer ticks - nymphs, are brown, the size of poppy seeds and very difficult to spot. An adult deer tick is only about the size of a sesame seed – still very small.

**Dog ticks** are the most common type of tick, and, while feeding, can be as large as a small pea. They have four pairs of legs, are reddish-brown and are easier to spot. Dog ticks turn gray while feeding. Ticks can be found throughout the year, but they are most active during the spring, early summer and fall, when it is warm and moist.

### What About Insect Repellent?

Two active ingredients found in repellents are DEET (the label may say N, N-diethyl-m-toluamide) and permethrin. Permethrin is only used on clothes. DEET repellents or products come in many different concentrations, with percentages as low as five percent or as high as 100 percent. In general, the higher the concentration the higher the protection, but the risk of negative health effects goes up too. Use the lowest concentration that you think will provide the protection you need. The New York State Health Department recommends taking these precautions when using repellents that contain these active ingredients:

- Store out of the reach of children and read all instructions on the label before applying.
- Do NOT allow children to apply repellents themselves.



# **Cyanobacteria**

## **What is cyanobacteria?**

Cyanobacteria, also known as blue-green algae, are naturally occurring bacteria that are present in Lake Champlain and other water bodies around the world. Like plants, they use photosynthesis to convert sunlight into energy. Usually cyanobacteria cannot be seen by the naked eye. However, under certain conditions, the algae grow prolifically and are visible as blooms. The blooms appear as a cloudy pea green accumulation in the water. Generally, these blooms of cyanobacteria occur when there is a balance of certain factors including: an abundance of available nutrients, warm surface water temperatures, and calm winds.

## **Why should be concerned?**

Unfortunately, certain types of blue-green algae produce toxins or poisons. When the algae die and break down, these toxins are released into the water. Exposure to these toxins have health impacts on humans and animals. Human health effects from cyanobacteria blooms vary depending on the type and duration of exposure (including inhalation of water droplets). In the summers of 1999 and 2000, the deaths of several dogs were linked to the cyanobacteria in Lake Champlain.



Photo source: Lake Champlain Basin Program

## **Identification and Avoidance: When in Doubt, Stay Out**

In general, blooms have the appearance of:

- Cloudy water as thick as pea soup or green paint on the water
- While generally green or blue-green in color, they can be brown or even purple
- A thick mat or foam may form as it accumulates onto shore

Blooms usually occur in August or September and can appear and disappear rapidly. There is no accurate way to identify the algae without a microscope. If you are suspicious, simply stay out of and away from the water.

## **References and Resources:**

Check Current Conditions Online:

[http://healthvermont.gov/enviro/bg\\_algae/weekly\\_status.aspx](http://healthvermont.gov/enviro/bg_algae/weekly_status.aspx)

Vermont Department of Health's Blue-Green Algae Guidance Document:

[http://healthvermont.gov/enviro/bg\\_algae/documents/BGA\\_guide.pdf](http://healthvermont.gov/enviro/bg_algae/documents/BGA_guide.pdf)

Websites:

[http://healthvermont.gov/enviro/bg\\_algae/bgalgae.aspx](http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx)

<http://www.lcbp.org/water-environment/human-health/cyanobacteria/>

<http://www.lakechamplaincommittee.org/lcc-at-work/algae-in-lake/>

Photo Galleries:

<http://www.lcbp.org/2012/12/photo-gallery-2008-cyanobacteria-blooms/>

[http://healthvermont.gov/enviro/bg\\_algae/photos.aspx#bg](http://healthvermont.gov/enviro/bg_algae/photos.aspx#bg)

**Report a Blue-green Algae Bloom:**

If you have questions or want to report a suspected bloom:

Call 1-800-439-8550 or 802-863-7220, or

email [AHS.VDHBlueGreenAlgae@state.vt.us](mailto:AHS.VDHBlueGreenAlgae@state.vt.us)

If you believe that someone has become ill because of exposure to blue-green algae, seek medical attention and contact the Health Department at 1-800-439-8550.

## Measuring Infiltration Rates

**This exercise is included in the manual for RACC teachers to use with their classes, if interested. It is not a required data collection task for your participation in the RACC Streams Project and these data will not be uploaded to the Streams Project database.**

### **Introduction:**

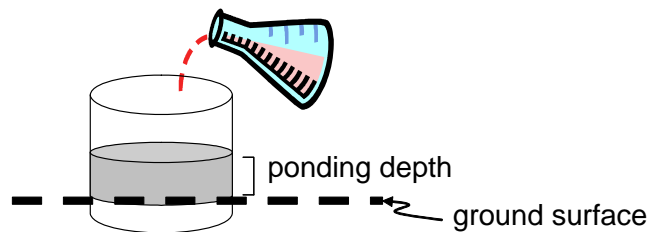
Infiltration is the movement of water into a soil profile. The rate at which infiltration occurs is controlled both by the inherent properties of the soil and by the ways in which humans have modified the landscape. Infiltration rates, in turn, control runoff rates and soil erosion, which are important because these processes influence the behavior of hillslopes. This exercise is designed to introduce you to a simple method for measuring infiltration rates. You will use a ring infiltrometer to measure infiltration at plots that represent differences in disturbance of the soil surface. You may also measure the soil bulk density and gravimetric moisture content at the measurement sites and compare these to measured infiltration rates.

### **Methods:**

Select two sites for measurement of soil properties and infiltration rates representing (1) a forested site showing no signs of noticeable compaction or human traffic, and (2) a site located on a designated hiking trail or one showing noticeable signs of compaction. You will extract soil cores from a location immediately adjacent to your infiltration test.

#### A. Infiltration test

1. Select a level site for your test. Remove loose debris (leaves, sticks) from an area the size of your infiltrometer (but do not pull up rooted plants; this will affect the pores in the soil).
2. Insert the ring infiltrometer several centimeters into the soil. Record this penetration depth. The ring should be inserted deeply enough and sealed adequately to the soil to preclude any leakage from the ring.
3. Fill out the top of the data sheet to record your group members and experimental set up.
4. To conduct the infiltration test, establish a standing pond of water within the ring that you maintain to within about 10% of this depth throughout the test. Once you have established this ponding depth, add water to maintain a constant ponding depth throughout your experiment. This should require frequent additions of water at the start of your experiment and less frequent additions as your test proceeds. Continue to make measurements of water additions for at least one hour, recording additions at least every 10 minutes, but more frequently if needed to maintain a constant ponding depth.



## B. Soil extraction for bulk physical properties

1. Immediately adjacent to each of your infiltration tests, extract a bulk sample of the mineral soil using the soil auger. Retain only the center ring of your extracted sample. Be sure to record the dimensions (diameter, length) of the device used to extract your sample.
2. Place the sample into a plastic bag, labeled with your name(s) and indicate whether it is from the “forest” or “trail” site.
3. In the lab, weigh an empty aluminum pan to determine the tare weight, then place your sample in the pan and weigh again. Place the soil sample in the oven for overnight drying at 103°C. When drying is complete, weigh the sample again to determine dry weight.

## C. Data reduction, analysis and interpretation

1. Use the data reduction instructions following each data sheet to make calculations from your raw field data.
2. Enter your infiltration data for both sites into a spreadsheet with columns to record time, elapsed time, volume of water added, and depth of water infiltrated at each time step. Your entries should include at least one hour of observations.
3. Plot the data in your spreadsheet as an x,y scatterplot with elapsed time on the x axis and infiltration rate on the y axis (see for example figure 5.4 in your textbook).
4. Estimate a steady state infiltration capacity from your data plot for both sites by taking an average of measurements over a time interval during which infiltration rate shows little or no change.
5. Consider/discuss:
  - How do the steady state infiltration rates differ between the two sites you measured?
  - What factors influence the rate at which infiltration occurs; how do your measurements of bulk density relate to any of these factors?
  - What are the limitations associated with inferring infiltration rates across the landscape based on the measurements you have made?



## Infiltration Test Data Sheet

Group member names: \_\_\_\_\_

Experiment date: \_\_\_\_\_

Location: \_\_\_\_\_

### Experimental Set-up

Diameter of infiltrometer (d): \_\_\_\_\_

Site type: forest | trail

Infiltrator length (cm) \_\_\_\_\_ Depth inserted into soil (cm) \_\_\_\_\_

Ponding depth (cm) \_\_\_\_\_

### DATA:

time (hr:min:sec)	volume start (ml)	volume end (ml)	volume added ( )		time (hr:min:sec)	volume start (ml)	volume end (ml)	volume added ( )
0:00:00	--	--	--					
	1000							

*Adapted from Measuring Infiltration Lab by Beverley Wemple, UVM Geography Department.  
Please do not distribute without permission.*

## Infiltration Test Data Sheet

Group member names: \_\_\_\_\_

Experiment date: \_\_\_\_\_

Location: \_\_\_\_\_

### Experimental Set-up

Diameter of infiltrometer (d): \_\_\_\_\_

Site type: forest | trail

Infiltrometer length (cm) \_\_\_\_\_ Depth inserted into soil (cm) \_\_\_\_\_

Ponding depth (cm) \_\_\_\_\_

### DATA:

time (hr:min:sec)	volume start (ml)	volume end (ml)	volume added ( )		time (hr:min:sec)	volume start (ml)	volume end (ml)	volume added ( )
0:00:00	--	--	--					
	1000							

### Data reduction:

*Adapted from Measuring Infiltration Lab by Beverley Wemple, UVM Geography Department.  
Please do not distribute without permission.*

To compute infiltration rates from your experiment, you will need to convert the volume of water to a water depth, then divide by the elapsed time. Follow the steps below to reduce your data and compute infiltration rates for each experiment. In each step, write the formula you use, then clearly show your calculations with units:

1. Calculate the surface area ( $A$ ) of the infiltrometer from the diameter of the ring. (4 pts)
2. For one time step on one your data sheet, compute depth of water infiltrated ( $D$ ) as the volume<sup>1</sup> of water ( $V$ ) divided by the surface area ( $a$ ) of the infiltrometer. Use an arrow on your data sheet to indicate the time step for which you are making this calculation. (4 pts)
3. For the time step used in #2 above, convert the elapsed time ( $t$ ) in minutes and seconds to time in hours (this should be a fraction of an hour). (3 pts)
4. Compute infiltration rate ( $I$ ) by dividing water depth ( $D$ ) by elapsed time ( $t$ ). Express your answer in cm/hr (4 pts)

<sup>1</sup> Note: Water volume for the experiment is measured in milliliters. 1 ml = 1 cm<sup>3</sup>.

## Bulk Density Data Sheet

Plot 1 (circle one): forest   trail	
Auger ring diameter (cm) _____	Auger ring length (cm) _____
Sample tare weight (g): _____	
Sample field weight (g): _____	
Sample dry weight (g): _____	
Notes on site conditions:	

Plot 2 (circle one): forest   trail	
Auger ring diameter (cm) _____	Auger ring length (cm) _____
Sample tare weight (g): _____	
Sample field weight (g): _____	
Sample dry weight (g): _____	
Notes on site conditions:	

### Data reduction:

To compute bulk density and gravimetric moisture content, you will need to calculate the volume of soil extracted, then weigh it to get mass of the soil and mass of water lost with drying. Follow the steps below to reduce your data. For each step, write the formula you use and clearly show your calculations with units:

Forest site:

1. Calculate ring volume. (3 pts)

2. Calculate the bulk density of the soil sample. (3 pts)

3. Calculate the gravimetric moisture content of the soil sample. (3 pts)

Trail site:

1. Calculate ring volume. (2 pts)

2. Calculate the bulk density of the soil sample. (2 pts)

3. Calculate the gravimetric moisture content of the soil sample. (2 pts)

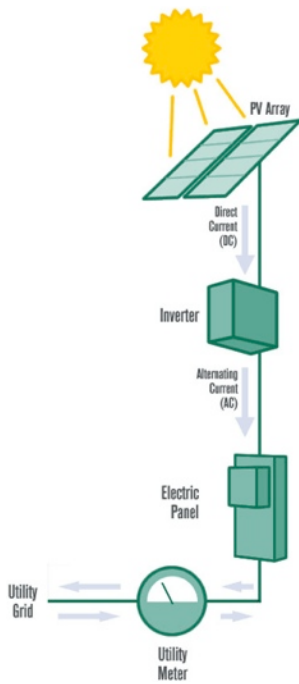


# Renewable Energy Vermont

## Solar Factsheet: *Electricity and hot water from the sun*

### What is Solar Power?

Solar power is the heat from the sun, and it is the foundation of all life on earth, allowing plants to grow and providing the warmth that makes our planet habitable. The sun is so powerful, and steady, that it beams more than enough energy to supply the planet's energy needs, every hour! Humans have organized their lives around the sun since the very beginning, designing systems to capture its energy for heating, cooking, and now, electrical and hot water needs.



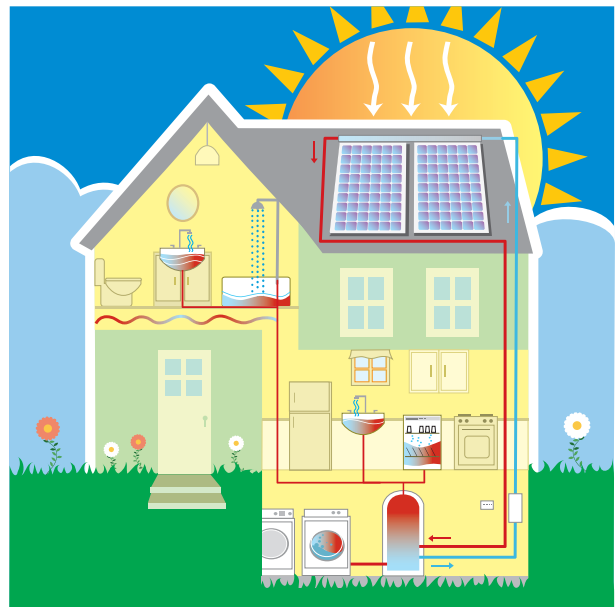
### How Do You Get Electricity From the Sun?

Modern solar photovoltaic, or PV, panels convert the sun's energy directly into electricity. PV panels are made out of thin wafers of silicon — the same basic building block of beach sand. As seen in the diagram to the **left**, Sunlight hitting the PV panels causes the electrons in the silicon wafers to move and bounce around rapidly, creating an electrical charge that is captured, converted to alternating current (AC) and used to power homes, businesses or whole communities.

### What Else Can Be Produced From the Sun?

The sun's energy can also be used to generate hot water for homes, or utility-scale electricity. Household solar thermal systems like the one on the **right** generally include a collector on

the roof, a liquid medium, and a holding tank inside the building. The liquid medium circulates through the collector and is heated by the sun; then it flows into the holding tank, heating up water for sinks and showers. Utility-scale solar thermal systems concentrate the sun's heat on a liquid medium, which becomes so hot that it boils; the steam is used to turn a turbine, generating electricity.



### Renewable Energy Vermont

Solar Factsheet // [www.revermont.org](http://www.revermont.org)

### Where is Solar Power Produced and Consumed?

Solar power can be produced, and consumed, anywhere in the world that the sun shines. Currently, the United States and the European Union are the biggest producers and consumers of solar PV and solar thermal heating. Solar PV usage grew 53 percent worldwide from 2008-9. By the end of 2009 there was approximately 20 Gigawatts (a typical non-CFL light bulb takes 60 watts to light up; a Gigawatt equals one *billion* watts!) of solar PV capacity installed around the planet, and 180 Gigawatts of solar thermal hot water producing capacity.



Green Mountain Power's Berlin, VT Solar Facility

### What Are the Benefits of Solar Power?

Compared to fossil fuel sources of electricity and hot water, solar energy is a zero-emissions solution, producing no climate-warming carbon dioxide, or polluting, harmful gasses. Solar power keeps power generation local, creating jobs and increasing our energy independence. Plus, once installed, solar power creates electricity and hot water for *free*!

### Did You

#### know?

If you take a look around the outside of your house or apartment building, you'll find an electric meter (like the one on the right here), which counts how much electricity your building uses. Buildings with solar PV installed often produce more electricity than they can use, and this extra power goes back into the power lines for other buildings to use. When this happens the electric meter actually runs backwards, giving the building owners a credit against their electric bill!



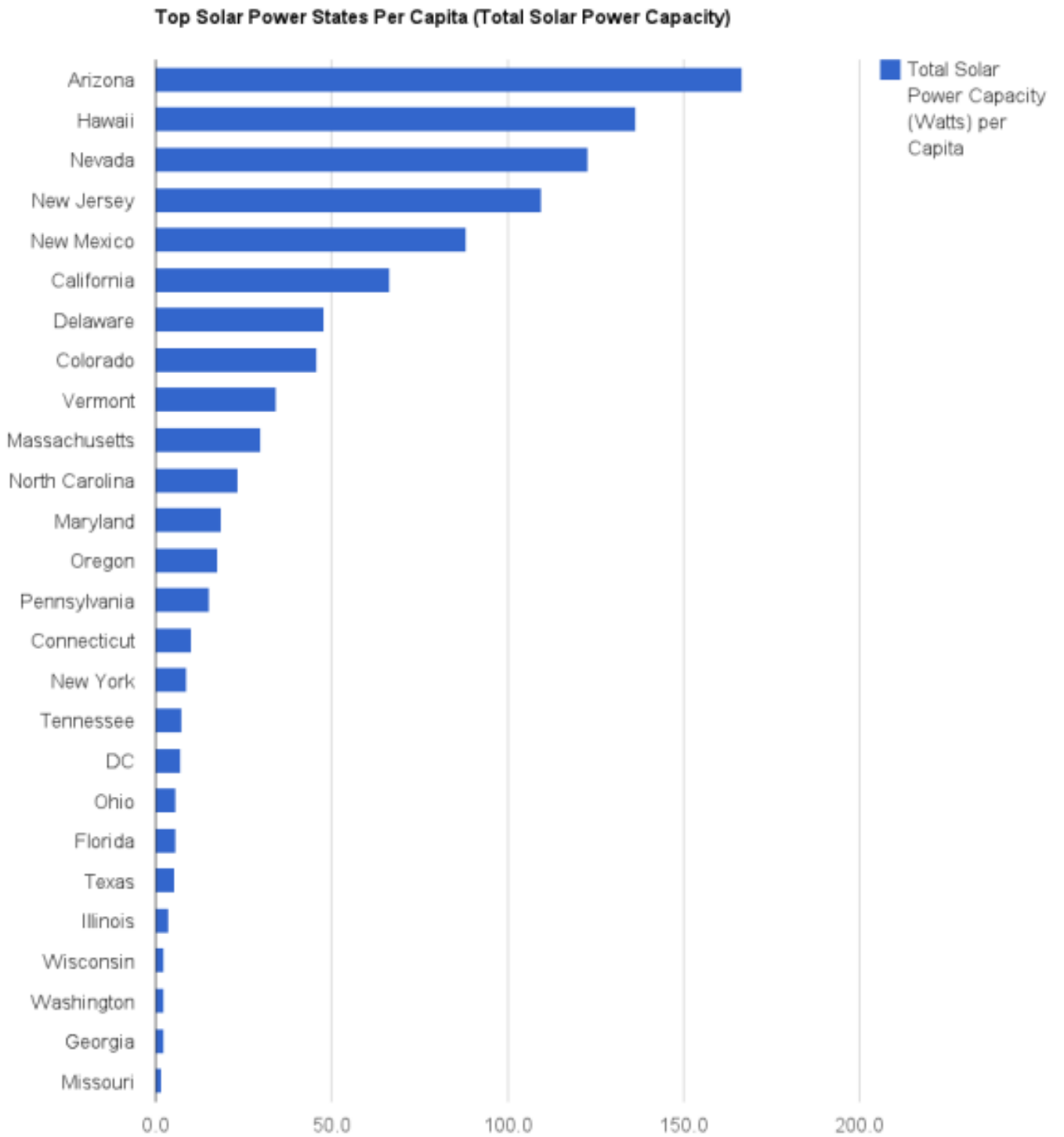
### Want to Find Out More About Solar Power?

We've got more information, links and resources at <http://www.revermont.org/main/technology/solar/>

### Renewable Energy Vermont

Solar Factsheet // [www.revermont.org](http://www.revermont.org)

Data as of 2012





State	Total Solar Power Capacity (Watts) per Capita	Total Solar Power Capacity (MW)	Population (2012)
Arizona	166.9	1,093.5	6,553,255
Hawaii	136.5	190.0	1,392,313
Nevada	122.9	339.1	2,758,931
New Jersey	109.6	971.4	8,864,590
New Mexico	88.4	184.4	2,085,538
California	66.7	2,537.4	38,041,430
Delaware	47.8	43.8	917,092
Colorado	46.0	238.5	5,187,582
Vermont	34.2	21.4	626,011
Massachusetts	29.7	197.6	6,646,144
North Carolina	23.5	229.1	9,752,073
Maryland	18.6	109.2	5,884,563
Oregon	17.7	69.1	3,899,353
Pennsylvania	15.4	196.3	12,763,536
Connecticut	10.2	36.6	3,590,347
New York	8.9	174.8	19,570,261
Tennessee	7.6	49.1	6,456,243
DC	7.3	4.6	632,323
Ohio	5.8	67.0	11,544,225
Florida	5.8	111.3	19,317,568
Texas	5.3	138.7	26,059,203
Illinois	3.6	46.2	12,875,255
Wisconsin	2.5	14.2	5,726,398
Washington	2.3	16.1	6,897,012
Georgia	2.3	22.5	9,919,945
Missouri	1.7	10.3	6,021,988

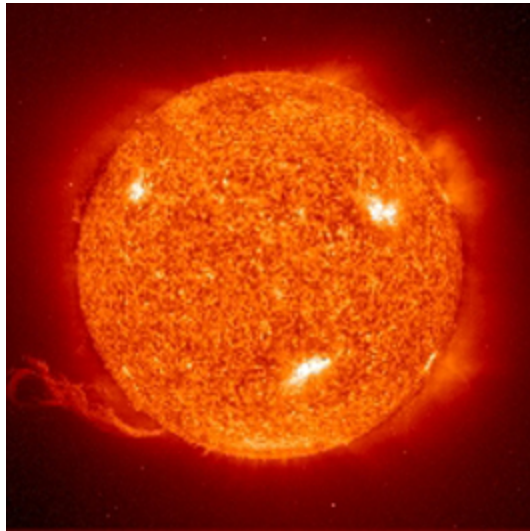
Image Credit: [Zachary Shahan](#) / [CleanTechnica](#). Data Credit: [GTM Research](#) / [SEIA](#).

Read more at <http://cleantechnica.com/2013/11/24/attractive-states-investing-solar/#zj6fLi2mAgxbCGh.99>

# Solar Basics

## Energy from the sun

The sun has produced energy for billions of years. Solar energy is the sun's rays (solar radiation) that reach the Earth. This energy can be converted into other forms of energy, such as heat and electricity.



Radiant energy from the sun has powered life on Earth for many millions of years.

Source: [NASA](#)

In the 1830s, the British astronomer John Herschel famously used a solar thermal collector box (a device that absorbs sunlight to collect heat) to cook food during an expedition to Africa. Today, people use the sun's energy for lots of things.

## Solar energy can be used for heat and electricity

When converted to **thermal (or heat) energy**, solar energy can be used to:

- Heat water — for use in homes, buildings, or swimming pools
- Heat spaces — inside homes, greenhouses, and other buildings
- Heat fluids — to high temperatures to operate a turbine to generate electricity

Solar energy can be converted to electricity in two ways:

- **Photovoltaic (PV devices) or “solar cells”** change sunlight directly into electricity. Individual PV cells are grouped into panels and arrays of panels that can be used in a wide range of applications ranging from single small cells that charge calculator and watch batteries, to systems that power single homes, to large power plants covering many acres.
- **Solar thermal/electric power plants** generate electricity by concentrating solar energy to heat a fluid and produce steam that is used to power a generator. In 2012, solar thermal-power generating units were the main source of electricity at 12 power plants in the United States: 11 in California and one in Nevada

The main benefits of solar energy are:

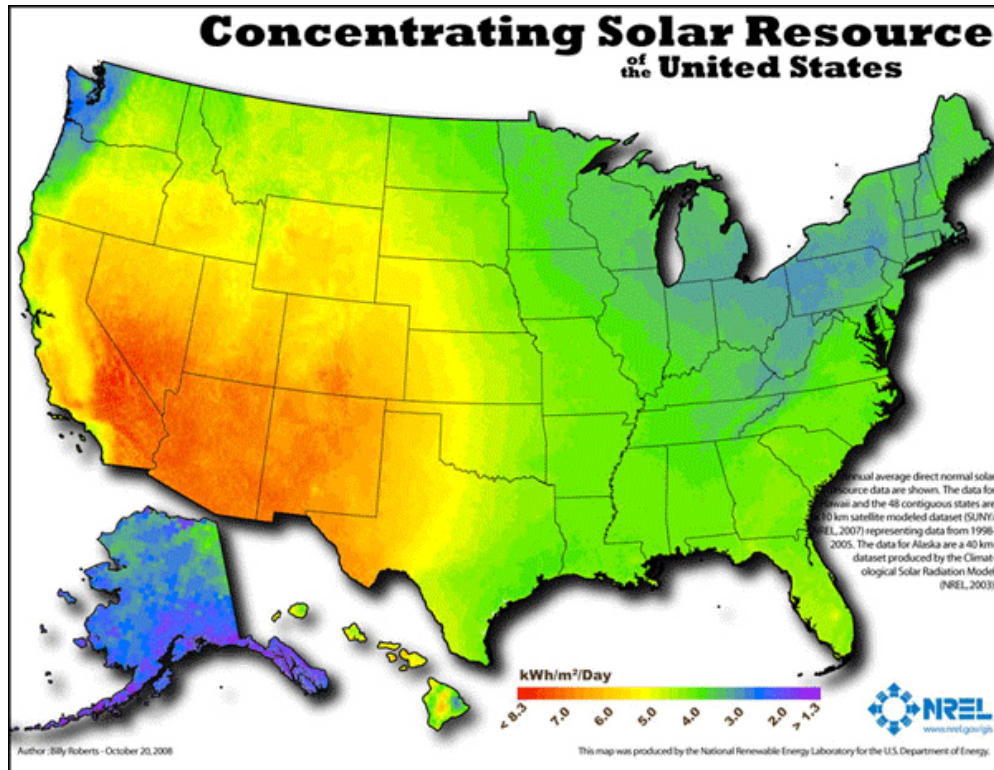
- Solar energy systems do not produce air pollutants or carbon-dioxide
- When located on buildings, they have minimal impact on the environment

Two limitations of solar energy are:

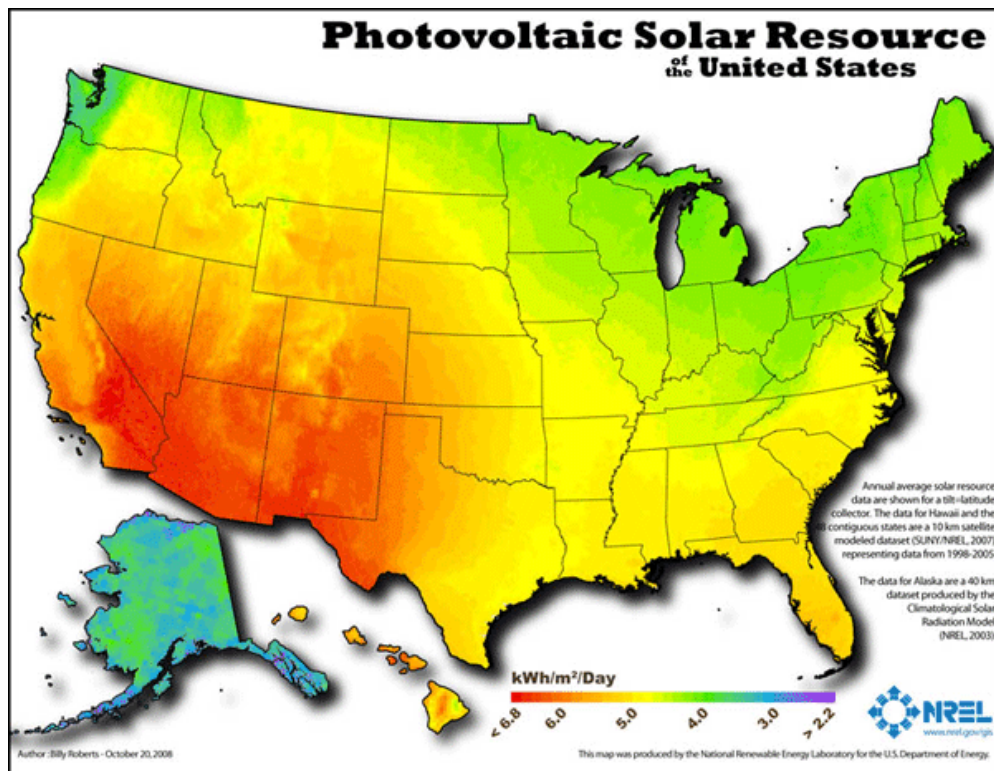
- The amount of sunlight that arrives at the Earth's surface is not constant. It varies depending on location, time of day, time of year, and weather conditions.
- Because the sun doesn't deliver that much energy to any one place at any one time, a large surface area is required to collect the energy at a useful rate.

## Where Solar is Found

The amount of solar energy that the earth receives each day is many times greater than the total amount of energy consumed around the world. However, solar energy is a variable and intermittent energy source. The amount and intensity of sunlight varies by location, and weather and climate conditions affect its availability on a daily and seasonal basis. The type and size of a solar energy collection and conversion system determines how much of available solar energy can be converted to useful energy.

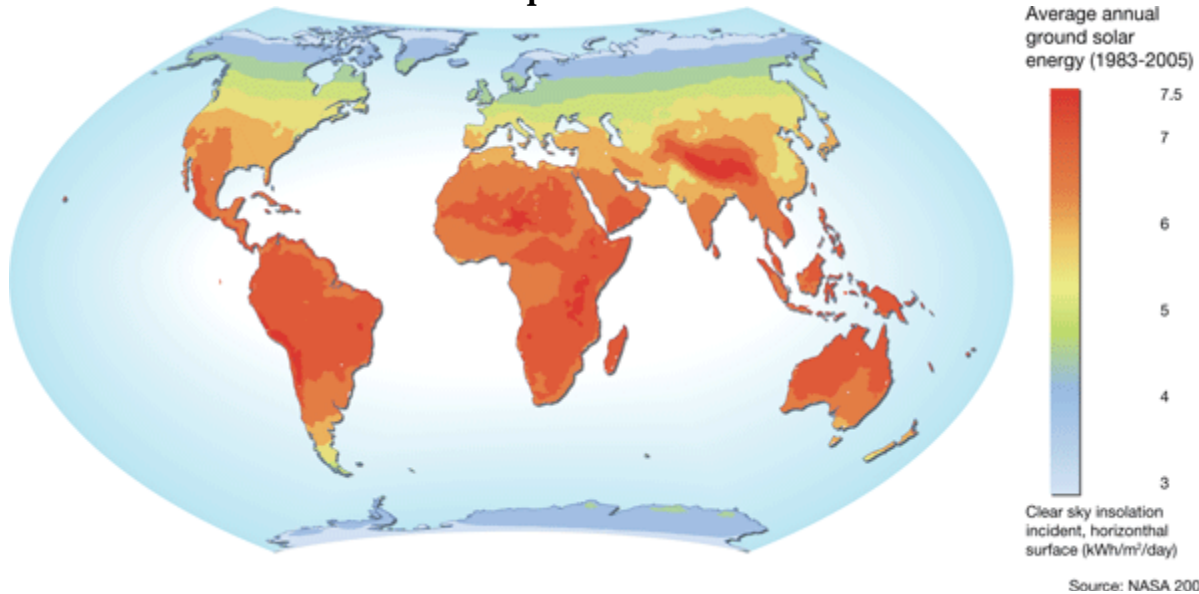


Source: National Renewable Energy Laboratory, U.S. Department of Energy



Source: National Renewable Energy Laboratory, U.S. Department of Energy

## World map of solar resources



Source: [United Nations Environment Programme \(UNEP\)](#), NASA Surface meteorology and Solar Energy (SSE), 2008.

## Solar thermal collectors

Low-temperature solar thermal collectors absorb the sun's heat energy to heat water or air for heating in homes, offices, and other buildings.

## Concentrating collectors

Concentrating solar power technologies use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat. This thermal energy can then be used to produce high temperature heat or electricity via a steam turbine or heat engine driving a generator.

## Photovoltaic systems

Photovoltaic cells (PV) convert sunlight directly into electricity. Photovoltaic systems can range from those that provide tiny amounts of power for watches and calculators up to those that provide the amount used by hundreds of homes.

Hundreds of thousands of houses and buildings around the world have PV systems on their roofs. Many multi-megawatt (MW) PV power plants have also been built. Covering 4% of the world's desert areas with photovoltaics could supply the equivalent of all of the world's electricity. The Gobi Desert alone could supply almost all of the world's total electricity demand.

## Solar Photovoltaic

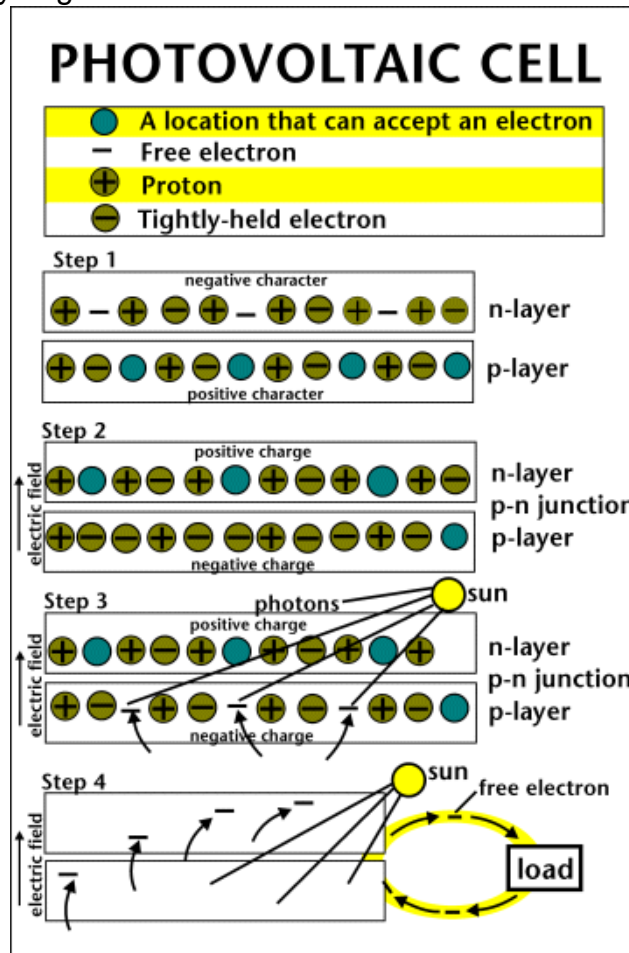


A photovoltaic cell, commonly called a solar cell or PV, is the technology used to convert solar energy directly into electrical power. A photovoltaic cell is a nonmechanical device usually made from silicon alloys.

## Photons carry solar energy

Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum.

When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity. When enough sunlight (energy) is absorbed by the material (a semiconductor), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface.



Source: National Energy Education Development Project (public domain)

## The flow of electricity

When the electrons leave their position, holes are formed. When many electrons, each carrying a negative charge, travel toward the front surface of the cell, the resulting imbalance of charge between the cell's front and back surfaces creates a voltage potential like the negative and positive terminals of a battery. When the two surfaces are connected through an external load, such as an appliance, electricity flows.

## How photovoltaic systems operate

The photovoltaic cell is the basic building block of a photovoltaic system. Individual cells can vary in size from about 0.5 inches to about 4 inches across. However, one cell only produces 1 or 2 watts, which isn't enough power for most applications.

To increase power output, cells are electrically connected into a packaged weather-tight module. Modules can be further connected to form an array. The term array refers to the entire generating plant, whether it is made up of one or several thousand modules. The number of modules connected together in an array depends on the amount of power output needed.

## Weather affects photovoltaics

The performance of a photovoltaic array is dependent upon sunlight. Climate conditions (such as clouds or fog) have a significant effect on the amount of solar energy received by a photovoltaic array and, in turn, its performance. The efficiency of most commercially available photovoltaic modules in converting sunlight to electricity ranges from 5% to 15%. Researchers around the world are trying to achieve efficiencies up to 30%.

## Commercial applications of photovoltaic systems

The success of PV in outer space first generated commercial applications for this technology. The simplest photovoltaic systems power many of the small calculators and wrist watches used every day. More complicated systems provide electricity to pump water, power communications equipment, and even provide electricity to our homes.

Some advantages of photovoltaic systems are:

1. Conversion from sunlight to electricity is direct, so bulky mechanical generator systems are unnecessary.
2. PV arrays can be installed quickly and in any size.
3. The environmental impact is minimal, requiring no water for system cooling and generating no by-products.

Photovoltaic cells, like batteries, generate direct current (DC), which is generally used for small loads (electronic equipment). When DC from photovoltaic cells is used for commercial applications or sold to electric utilities using the electric grid, it must be converted to alternating current (AC) using inverters, solid state devices that convert DC power to AC.

## History of the photovoltaic cell

The first practical PV cell was developed in 1954 by Bell Telephone researchers examining the sensitivity of a properly prepared silicon wafer to sunlight. Beginning in the late 1950s, PV cells were used to power U.S. space satellites. PV cells were next widely used for small consumer electronics like calculators and watches and to provide electricity in remote or "off-grid" locations where there were no electric power lines. Technology advances and government financial incentives have helped to greatly expand PV use since the mid-1990s.

U.S. shipments (includes imports, exports, and domestic shipments) of PV panels (modules) by U.S. industry in 2012 was the equivalent of about 4,655 Megawatts, about 245 times greater than the shipments of about 19 Megawatts in 1994<sup>1</sup>. Since about 2004, most of the PV panels installed in the United States have been in "grid-connected" systems on homes, buildings, and central-station power facilities. There are PV products available that can replace conventional roofing materials.

<sup>1</sup>Earliest year for which data are available.

## Solar Thermal Power Plants

### **Solar thermal power uses solar energy instead of combustion**

Solar thermal power plants use the sun's rays to heat a fluid to very high temperatures. The fluid is then circulated through pipes so it can transfer its heat to water to produce steam. The steam, in turn, is converted into mechanical energy in a turbine and into electricity by a conventional generator coupled to the turbine.



So solar thermal power generation works essentially the same as generation from fossil fuels except that instead of using steam produced from the combustion of fossil fuels, the steam is produced by the heat collected from sunlight. Solar thermal technologies use concentrator systems to achieve the high temperatures needed to heat the fluid.

The three main types of solar thermal power systems are:

1. Parabolic trough (the most common type of plant)
2. Solar dish
3. Solar power tower

## Types of solar thermal power plants

### Parabolic troughs

Parabolic troughs are used in the largest solar power facility in the world located in the Mojave Desert at Kramer Junction, California. This facility has operated since the 1980s and accounts for the majority of solar electricity produced by the electric power sector today.

A parabolic trough collector has a long parabolic-shaped reflector that focuses the sun's rays on a receiver pipe located at the focus of the parabola. The collector tilts with the sun as the sun moves from east to west during the day to ensure that the sun is continuously focused on the receiver.

Because of its parabolic shape, a trough can focus the sun at 30 to 100 times its normal intensity (concentration ratio) on the receiver pipe located along the focal line of the trough, achieving operating temperatures over 750°F.

The "solar field" has many parallel rows of solar parabolic trough collectors aligned on a north-south horizontal axis. A working (heat transfer) fluid is heated as it circulates through the receiver pipes and returns to a series of "heat exchangers" at a central location. Here, the fluid circulates through pipes so it can transfer its heat to water to generate high-pressure, superheated steam. The steam is then fed to a conventional steam turbine and generator to produce electricity. When the hot fluid passes through the heat exchangers, it cools down, and is then recirculated through the solar field to heat up again.



The plant is usually designed to operate at full power using solar energy alone, given sufficient solar energy. However, all parabolic trough power plants can use fossil fuel combustion to supplement the solar output during periods of low solar energy, such as on cloudy days.

## Parabolic trough power plant

Source: Stock photography (copyrighted)

## Solar Dish

A solar dish/engine system uses concentrating solar collectors that track the sun, so they always point straight at the sun and concentrate the solar energy at the focal point of the dish. A solar dish's concentration ratio is much higher than a solar trough's, typically over 2,000, with a working fluid temperature over 1380°F. The power-generating equipment used with a solar dish can be mounted at the focal point of the dish, making it well suited for remote operations



or, as with the solar trough, the energy may be collected from a number of installations and converted to electricity at a central point.

The engine in a solar dish/engine system converts heat to mechanical power by compressing the working fluid when it is cold, heating the compressed working fluid, and then expanding the fluid through a turbine or with a piston to produce work. The engine is coupled to an electric generator to convert the mechanical power to electric power.

## Solar Dish

Source: Stock photography (copyrighted)

## Solar power tower

A solar power tower, or central receiver, generates electricity from sunlight by focusing concentrated solar energy on a tower-mounted heat exchanger (receiver). This system uses hundreds to thousands of flat, sun-tracking mirrors called heliostats to reflect and concentrate the sun's energy onto a central receiver tower. The energy can be concentrated as much as 1,500 times that of the energy coming in from the sun.

Energy losses from thermal-energy transport are minimized because solar energy is being directly transferred by reflection from the heliostats to a single receiver, rather than being moved through a transfer medium to one central location, as with parabolic troughs.

Power towers must be large to be economical. This is a promising technology for large-scale grid-connected power plants. Power towers are in the early stages of development compared with parabolic trough technology.

The U.S. Department of Energy, along with a number of electric utilities, built and



operated a demonstration solar power tower near Barstow, California, during the 1980s and 1990s.

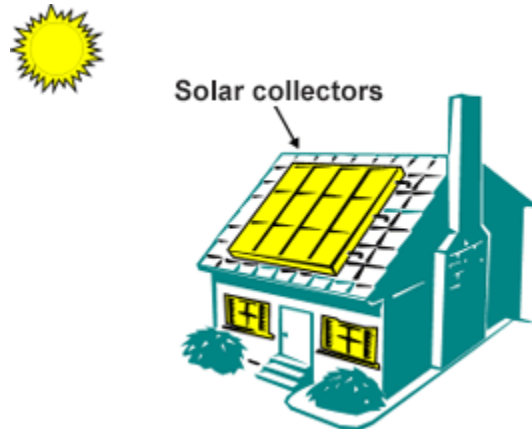
Projects from private companies include:

- a 5-Megawatt, two-tower project, built in the Mojave Desert in southern California in 2009
- a 390-Megawatt, three-tower project being built in the Mojave Desert
- a 110-Megawatt project located in Nevada

### Solar power tower

Source: [National Renewable Energy Laboratory \(NREL\)](http://www.nrel.gov)

# Solar Thermal Collectors



## Heating with the sun's energy

Source: National Energy Education Development Project (public domain)

Solar thermal (heat) energy is often used for heating water used in homes and swimming pools and for heating the insides of buildings ("space heating"). Solar space heating systems can be classified as **passive** or **active**.

**Passive** space heating is what happens to your car on a hot summer day. The sun's rays heat up the inside of your car. In buildings, the air is circulated past a solar heat surface and through the building by convection (meaning that less dense warm air tends to rise while denser cool air moves downward). No mechanical equipment is needed for passive solar heating.

**Active** heating systems require a **collector** to absorb and collect solar radiation. Fans or pumps are used to circulate the heated air or heat absorbing fluid. Active systems often include some type of energy storage system.

## Solar collectors are either nonconcentrating or concentrating

**Nonconcentrating collectors** — The collector area (the area that intercepts the solar radiation) is the same as the absorber area (the area absorbing the radiation).

**Flat-plate collectors** are the most common type of nonconcentrating collector and are used when temperatures below about 200°F are sufficient. They are often used for heating buildings.

There are many flat-plate collector designs but generally all consist of:

- A flat-plate absorber that intercepts and absorbs the solar energy
- A transparent cover(s) that allows solar energy to pass through but reduces heat loss from the absorber

- A heat-transport fluid (air or water) flowing through tubes to remove heat from the absorber, and a heat insulating backing

**Concentrating collectors** — The area intercepting the solar radiation is greater, sometimes hundreds of times greater, than the absorber area.

## Solar Energy & the Environment



An array of solar photovoltaic panels supplies electricity for use at Marine Corps Air Ground Combat Center in Twentynine Palms, California

Source: U.S. Marine Corps photo by Pfc. Jeremiah Handeland/Released (public domain)

Using solar energy produces no air or water pollution and no greenhouse gases, but may have some indirect negative impacts on the environment. For example, there are some toxic materials and chemicals that are used in the manufacturing process of photovoltaic cells (PV), which convert sunlight into electricity. Some solar thermal systems use potentially hazardous fluids to transfer heat. U.S. environmental laws regulate the use and disposal of these types of materials.

As with any type of power plant, large solar power plants can affect the environment where they are located. Clearing land for construction of the power plant may have long term impacts on plant and animal life. They may require water for cleaning solar collectors or concentrators and for cooling turbine-generators. Using ground water from wells may affect the ecosystem in some arid locations. Birds and insects can be killed if they fly into a concentrated beam of sunlight created by a "solar power tower."

# Glossary

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## #

#30 sieve - A strainer that the contents of the kick net is emptied into to remove unwanted debris. The sample material remaining is placed in whirlpacks.

## A

Attached Algae - Algae that has grown attached to a solid object or organism.

## B

Bank Full Width - Width of a stream bank at full flood stage.

Bank Stability - The ability of a stream bank to counteract erosion or gravitational forces.

Baseline Sample - A sample of the quality of water when the body of water is at a normal or resting state. This can be used later on as a comparison to samples that are taken during or after storms.

Benthic Macroinvertebrates - Organisms that do not have spines, and are generally small, but visible without a microscope. They are abundant near bodies of water and surrounding ecosystems, and usually live in water at some stage of their lives.

Berm - A level space, shelf, or raised barrier separating two areas. These are constructed to control runoff and direct flow.

Bioassessment - (or Biological Assessment) A method of assessing aquatic conditions by surveying biological organisms, such as macroinvertebrates, fish, or plants.

Biological Sampling - Conducting a survey of biological organisms used for beneficial research.

## C

Canopy Cover - The amount of sky covered by trees and vegetation over a stream bank.

Channel - In the context of this research, refers to the physical confinement of a stream that the water flows through, consisting of the stream bed and banks.

Channelized - Is the straightening and modification of a river corridor as a way to control the water. However, it is difficult to maintain a straight river, as the water tends to erode along the banks to return to a natural winding river.

Channel Sinuosity - A stream's natural ability to bend and wind, an important characteristic of rivers to divert high flows and carry/deposit sediment.

Chemical Constituents - The amount of oil, alcohols, aldehydes, esters, ketones, lactones, phenols and terpenes in a water sample.

Cross sectional area - The area of a slice of river, perpendicular to flow; used to help determine stream velocity.

## **D**

Deposition - The accumulation of material out of the water and onto the stream bed.

Didymo (Rock Snot) - A type of freshwater algae that is a nuisance when it blooms, creating thick, brown mats on the streambed. It is found in certain areas of Vermont, therefore waders and nets are decontaminated after use to avoid spreading it.

Discharge (flow) - The rate that a volume of water (and its associated suspended solids, dissolved chemicals, and biological materials) flows over a specific time. Usually provided in cubic feet per second.

Dissolved Oxygen - A relative measure of the amount of oxygen that is dissolved or carried in the stream water.

Dredging - The scooping and removal of sediment etc. from the bottom of a stream.

## **E**

Ecological Integrity - The abundance and diversity of organisms at all levels, and the ecological patterns, processes, and structural attributes responsible for that biological diversity and for ecosystem resilience.

Eddies - The swirling of stream water, usually downstream and past a barrier.

Embeddedness - How much of an object is submerged into the substrate under the water.

Epifaunal - Animals that live on the surface of substrate, such as rocks, pilings, vegetation, or the streambed itself.

Ethanol - A form of alcohol that is used to clean lab materials, as well as to preserve insect specimens.

## **F**

Floating Algae - Algae that is not attached to anything, typically refers to mats of algae that have accumulated and are growing together on the water's surface.

Free Floating Algae- Algae that is not attached to anything, such as duckweed.

## **H**

Habitat Assessment Data Sheet - A field sheet used to determine habitat parameters of a stream site.

Habitat Equality - The balance of things within a given habitat.

Headwaters - A tributary stream of a river close to or forming part of its source.

## **I**

iButton - A sensor that measures and records temperature. It works by transferring data in and out of the sensor when it is connected by a USB device.

iButton Capsule - A capsule that protects the iButton from environmental conditions such as temperature, moisture, pressure, and solvents, and allows the iButton to be securely mounted in a stream environment.

Infiltration - The movement of water into and through soil.

In Situ Measurements - Standard parameters that can be taken on the stream site with a water quality instrument.

## **J**

## **K**

Kick net - A net that is placed, with the opening facing upstream, into the riverbed with the motive of capturing benthic macroinvertebrates. While holding the net stable against the stream bottom, the researcher kicks and stirs up the sediment in front of the net, capturing any organisms living in and around the area.



## **L**

Large Woody Debris - Large pieces of wood found in streams, that acts as important habitat for aquatic organisms.

## **M**

Macroinvertebrates - see *Benthic Macroinvertebrates*

Macroinvertebrate Data Sheet - A sheet which records the conditions of the stream. This includes pebble count, canopy cover, temperature, water velocity, pH, and width data. It is used to record Macroinvertebrate collecting locations.

Macroinvertebrate Habitat Data Sheet - A field sheet that focuses on macroinvertebrates. It includes the pebble count.

## **N**

Nitrogen - An odorless and colorless element that makes up about 78% of the earth's atmosphere and is necessary for life to exist. Too much dissolved nitrogen in a water source can lead to eutrophication.

NOAA - Stands for the National Oceanic and Atmospheric Administration, a Department of Commerce agency that maps out oceans, predicts climate changes, provides weather and natural disaster reports, and helps conserve oceanic resources.

## **O**

One-Wire Viewer - iButton temperature sensor software for your computer. A Java demonstration application for iButton that features from your PC.

Orthophosphate - A lone phosphate molecule, a phosphorus atom connected to four oxygen atoms. Orthophosphate is directly taken up by algae .

Outfalls - The place where a river, drain, or sewer empties into the sea, a river, or a lake.

## **P**

Pebble Count - The tallying of 100 or more random sediment samples, measured by walking up and downstream in a zig-zag pattern and selecting random points to measure along the way.

Phosphorus - A solid, nonmetal element (P) that is necessary for life and typically exists in nature as a phosphate molecule (PO<sub>4</sub>). Inorganic and organic phosphorus can be dissolved or suspended in water and too much phosphorus in a water source can lead to eutrophication.

Physical Characterization - The physical things that describe the stream.

Physical Constituents - The physical makeup of a stream.

Pools - Deep parts of streams that typically occur after riffles.

Poison ivy - A toxic, flowering plant with three leaves that is common locally. It is known for irritating skin that comes in contact with it.

Poison parsnip - A common, local, flowering plant with yellow flowers. Can be an irritant if the inner sap is exposed and comes in contact with skin.

## Q

Quaternary Ammonium Disinfectant - A combination of water and quaternary ammonium (QUAT) that is used to sanitize waders after using them; ensuring that nothing harmful is transmitted when they are transported.

## R

RACC - Stands for Research on Adaptation to Climate Change that aims to answer the following overarching question: How will the interaction of climate change and land use alter hydrological processes and nutrient transport from the landscape, internal processing and eutrophic state within the lake and what are the implications for adaptive management strategies?

Replicate Number - The numbering of multiple samples for the purpose of organization.

Riffles - A rocky or shallow part of a stream or river with rough water that is typically high in dissolved oxygen.

Riparian Zone - The area between land and river or stream.

Riprap - Loose stone used to form a foundation for a breakwater or other structure.

Rooted Emergent - Refers to a plant that is rooted in sediment below a body of water, such as cattails.

Rooted Floating - Refers to an aquatic plant that is rooted below a body of water that floats to the top, such as lilies.

Rooted Submergent - Sediment rooted under a body of water that does not stick out, such as water milfoil.

## S

Sample ID Number - Located at the top of the Macroinvertebrate Data Sheet, this ID Number consists of yy/mm/dd and the Replicate number.

Sensor Field Data Sheet - To be completed at each field site; records temperature and sage sensor data.

Snag - In aquatic systems, this refers to trees and branches that have fallen into the stream.

Stage Sensor (HOBO Water Level Logger) - A battery powered device that is used by RACC which measures stage or water level of fresh water streams.

Stream Gradient - The slope of a stream. How to know if your stream site is high or low gradient:

1. Determine the stream type using this chart below.
  - a. Is your stream site confined by valley walls?
  - b. What is the general valley slope of your site?
    - i. Valley width is important because it is an indicator of how confined the stream is and whether it will have access to a floodplain at different flood levels. To determine valley width differences look for relative changes in the distance between toes of opposing valley walls. The toe of a valley wall can be identified as the bottom of the more steeply sloped portion of the valley.
    - ii. If your site is unconfined by valley walls and <2% slope (think fairly flat, not down a steep hill, the water has access to a floodplain when it rains, etc) you'd classify it as a type C stream.
    - iii. If your site has a steeper slope and valley walls that confine the stream (does it have room to meander or change course?), you'd classify it as a type A stream.

**Table 2.2 Phase 1 – Reference Stream Typing Chart**

Reference Stream Type	Confinement (Valley Type)	Valley Slope
A	Narrowly confined (NC)	Very Steep > 6.5 %
A	Confined (NC)	Very Steep 4.0 - 6.5 %
B	Confined or Semi-confined (NC, SC)	Steep 3.0 - 4.0 %
B	Confined or Semi-confined or Narrow (NC, SC, NW)	Mod.- Steep 2.0 – 3.0 %
C or E	Unconfined (NW, BD, VB)	Mod.- Gentle < 2.0 %
D	Unconfined (NW, BD, VB)	Mod.- Gentle < 4.0 %

2. Once you know what your stream type is, you can use the table below to determine if your site is high or low gradient.
  - a. If your site is a type C stream, think about the substrate. Is the stream mostly gravel, cobble, or boulders? If so, you're in a high gradient stream.
  - b. If your site is a type C stream but has mostly sand or fine gravel substrate, your site is a low gradient stream.

When to use high gradient RHA field form	When to use low gradient RHA field form
- reference stream type is A or B	- reference stream type is E
- reference stream type is C characterized by riffle/pool bed features and a dominant substrate size of gravel or larger	- reference stream type is C with ripple/dune or riffle/pool bed features and dominant substrate size is fine gravel, sand or smaller

For example, our training week field sites are classified below:

*Potash Brook:*

Stream Type: C  
 Substrate: Gravel and larger (cobbles)  
 Classification: High Gradient

*Allen Brook:*

Stream Type: C  
 Substrate: Sand and silt  
 Classification: Low Gradient

*Munroe Brook:*

Stream Type: B

Classification: High Gradient

*Indian Brook (by Essex High School):*

Stream Type: C

Substrate: Sand and silt

Classification: Low Gradient

*Indian Brook (by Mill Pond):*

Stream Type: C

Substrate: Gravel and larger (cobbles)

Classification: High Gradient

Stream Reach - A section of stream having relatively uniform physical attributes, such as confinement, valley slope, sinuosity, dominant bed material, sediment regime, tributary influence, and bed form. Reach determinations do not take into account human disturbances, but rather are based on variables related to valley setting, stream morphology, and their inherent fluvial processes.

Stream Site Code - A code given to any stream being tested so it can be easily identified in a lab.

Stream Site General Assessment Data Sheet - A field sheet that is filled out annually for a stream site. It provides general information about the location, surrounding area, and watershed features (such as a nearby dam or bridge).

Stream Stage - The height (typically in ft) of water from an established point, typically from stream bottom to surface. Often maintained by the USGS and can be measured in a variety of ways.

Substrate - Represents the variety of material that is present in the stream, ranging from clay and gravel, to boulder and bedrock, and includes woody debris. Refer to the following table for sizes:

Clay/Silt/Sand	< 0.004-2.0	Fine, granular pieces of sediment measuring under 2.0 cm
Gravel	2.0-16	Small rocks measuring 16 cm or less
Course gravel	16-64	Larger (softball size or bigger) rocks that are smaller than 64 cm
Cobble	64-256	Chunks of rock that are not large enough to be boulders but are still noticeably sizeable.
Boulder	>256	Large Rock measuring above 256 cm, tall (relative to surrounding sediment) and above the bedrock.
Bedrock	---	Solid rock, providing a base layer over which there are other sediments.

## T

Thalweg - A line connecting the lowest or deepest points of successive cross-sections along the course of a valley or river. This where the largest volume of water flows within the stream.

Ticks - Small, parasitic (blood sucking) organisms found locally. May transmit diseases including Lyme disease. Following time in the field, researchers should check for ticks on clothing and exposed skin.

Total Suspended Solids (TSS) - The total amount of suspended solids in a sample of water; listed as a pollutant in the US Clean Water Act and is therefore measured as a water quality indication. Includes mostly sediment and algae.

Total phosphorus (test) - A test that measures all phosphorus forms, such as orthophosphate, condensed phosphate, and organic phosphate, in a given sample of water.

Tributaries - A river or stream flowing into a larger river or lake.

Turbidity - The cloudiness of water caused by small particles.

## U

USB adaptor - An adapter that allows information to be directed between the iButton and a computer via a USB port.

USEPA - Stands for the United States Environment Protection Agency, a US federal agency that protects human health and the environment through enforcing regulations and laws passed by Congress.

USGS - Stands for the US Geological Survey, a US federal agency that studies the landscape of the United States and its natural resources and hazards.

## V

Valley Slope - While you don't need to calculate the actual valley slope, it is good to know how the calculation is done.

### Example – Calculating Valley Slope

1140 ft	upstream elevation
- 1000 ft.	downstream elevation
140 ft	change in elevation
$\frac{\text{difference in elevation (ft.)}}{\text{length of valley (ft.)}}$	$= \frac{140}{4,000} = 0.035 \times 100 = 3.5 \% \text{ valley slope}$

Velocity - In this context, the speed at which the water is flowing downstream.

## **W**

Water Quality Assessment - An evaluation of the conditions of a body of water. Specifically, biologically and chemically assessing and analyzing components such as flow, pH, TSS and nutrients of the body of water.

Water Quality Monitoring - Sampling and analysis of water constituents and conditions such as pollutants, natural components, dissolved chemicals, bacteria, etc. to know the base condition and target changes that may occur.

Water Quality Parameters - The general measurements of water that are healthy.

Watershed - An area or ridge of land that separates waters flowing to different rivers, basins, or seas.

Wetted Width - The width of the water in a stream bank.

Whirlpicks - Small bags that captured specimen are placed in after being captured in the kick net. Following this step, add ethanol for preservation.

## **X**

## **Y**

## **Z**