PENNSTATE Air Quality Learning & Demonstration Center

THE ARBORETUM AT PENN STATE

Advanced Teacher Training on Air Pollution Effects on Plants at the Air Quality Learning and Demonstration Center at the Arboretum at Penn State


WELCOME
THE AIR QUALITY LEARNING
AND DEMONSTRATION CENTER
AT THE
ARBORETUM, PENN STATE
BLACK
CHERRY
ESTABLISHED
SUMMER, 2002
MILKWEED


Air Quality Monitoring Building
LCD Public Display of
Real-Time Air Quality Data
Forest and Bio-indicator
Species
Teaching Pavilion
Open-Top Chambers
Agricultural Garden


THE AIR QUALITY LEARNING
AND DEMONSTRATION CENTER

Objectives

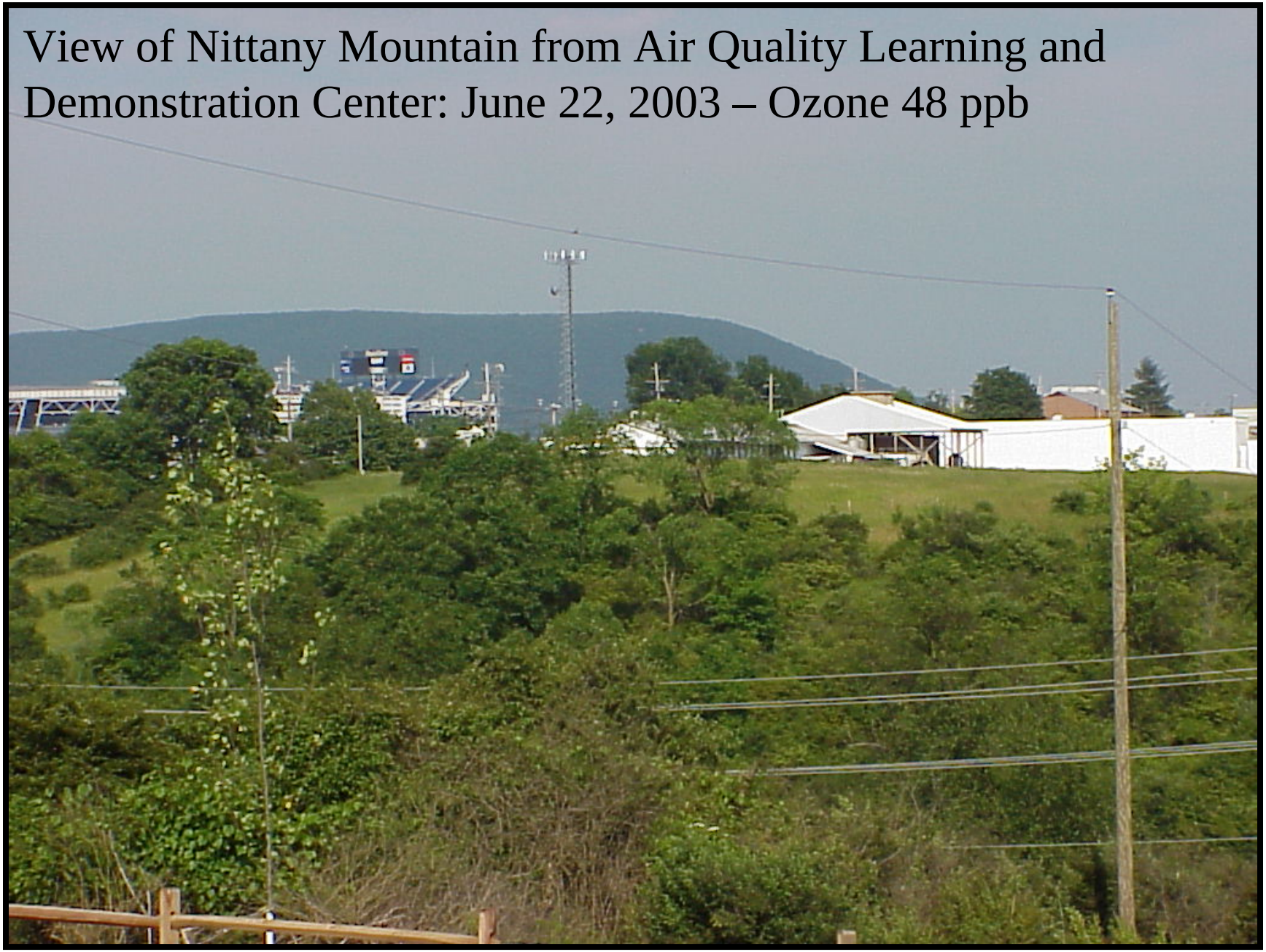
- Develop an interactive Air Quality Monitoring & Learning and Demonstration facility within the Penn State Arboretum.
- Maintenance of gardens of agricultural, forest tree and native plant species known to be sensitive to air pollution (bio-indicators).
- Employment of several research techniques that demonstrate the effect of air pollutants on vegetation.
- Provide an educational center for the general public, students, and educators where the most recent findings of our national research programs of air pollution effects on vegetation will be presented and displayed.
- Provide an educational center where the newest air pollution control and abatement technologies and strategies may be presented.

Monitoring for Air Pollutants

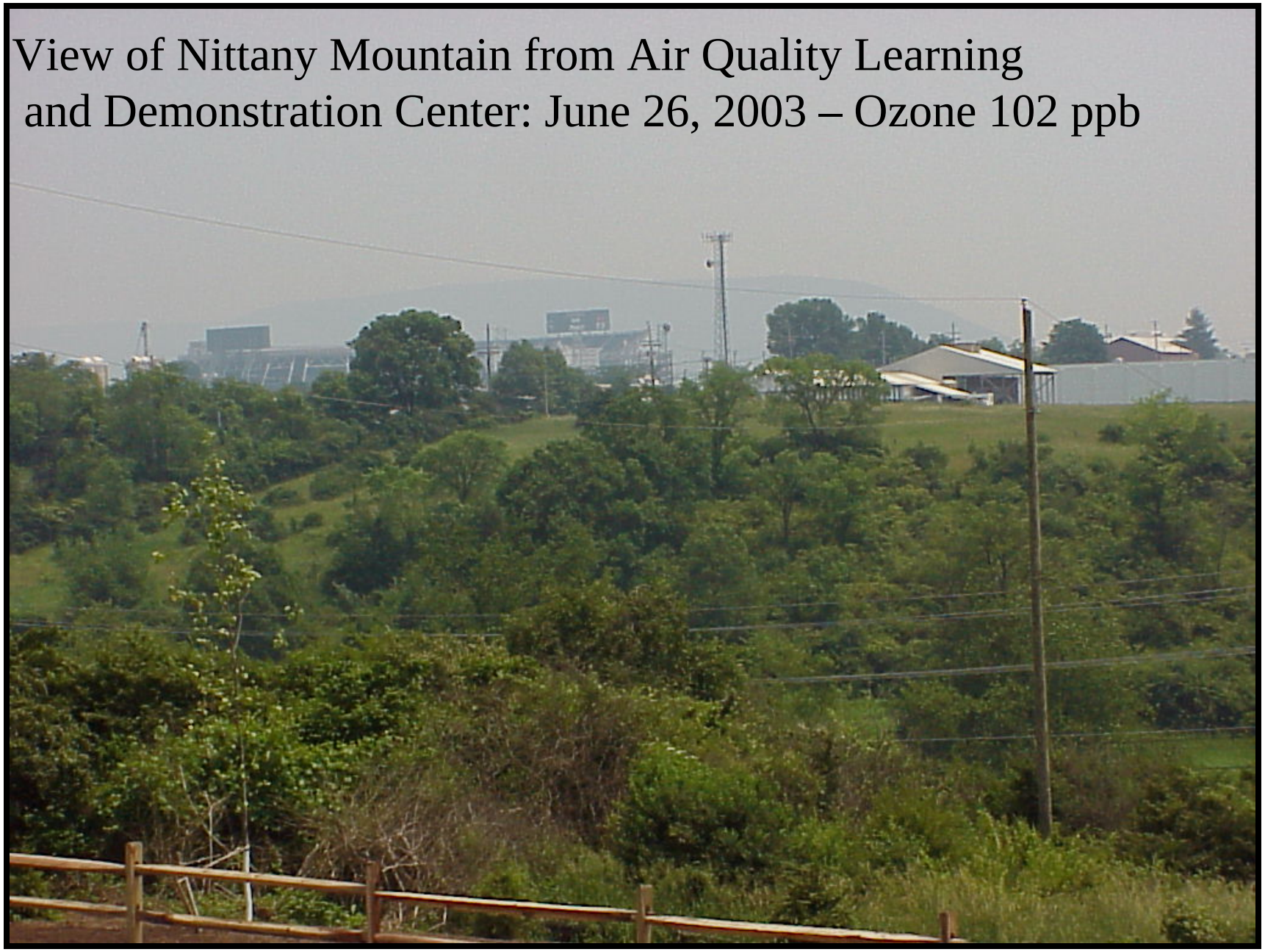
Instrumentation

- Ambient ozone, sulfur dioxide, nitrogen oxides, carbon dioxide, PM 2.5 and speciation.
- Wind speed and direction, temperature, relative humidity, solar radiation, rainfall, soil moisture, visibility.
- Web camera for visibility, chamber cameras.
- LCD screen outside for display of all monitored data.
- Information kioske to display continuous and interactive information concerning the center.
- http://www.aireffects.psu.edu/envidasweb/company.asp

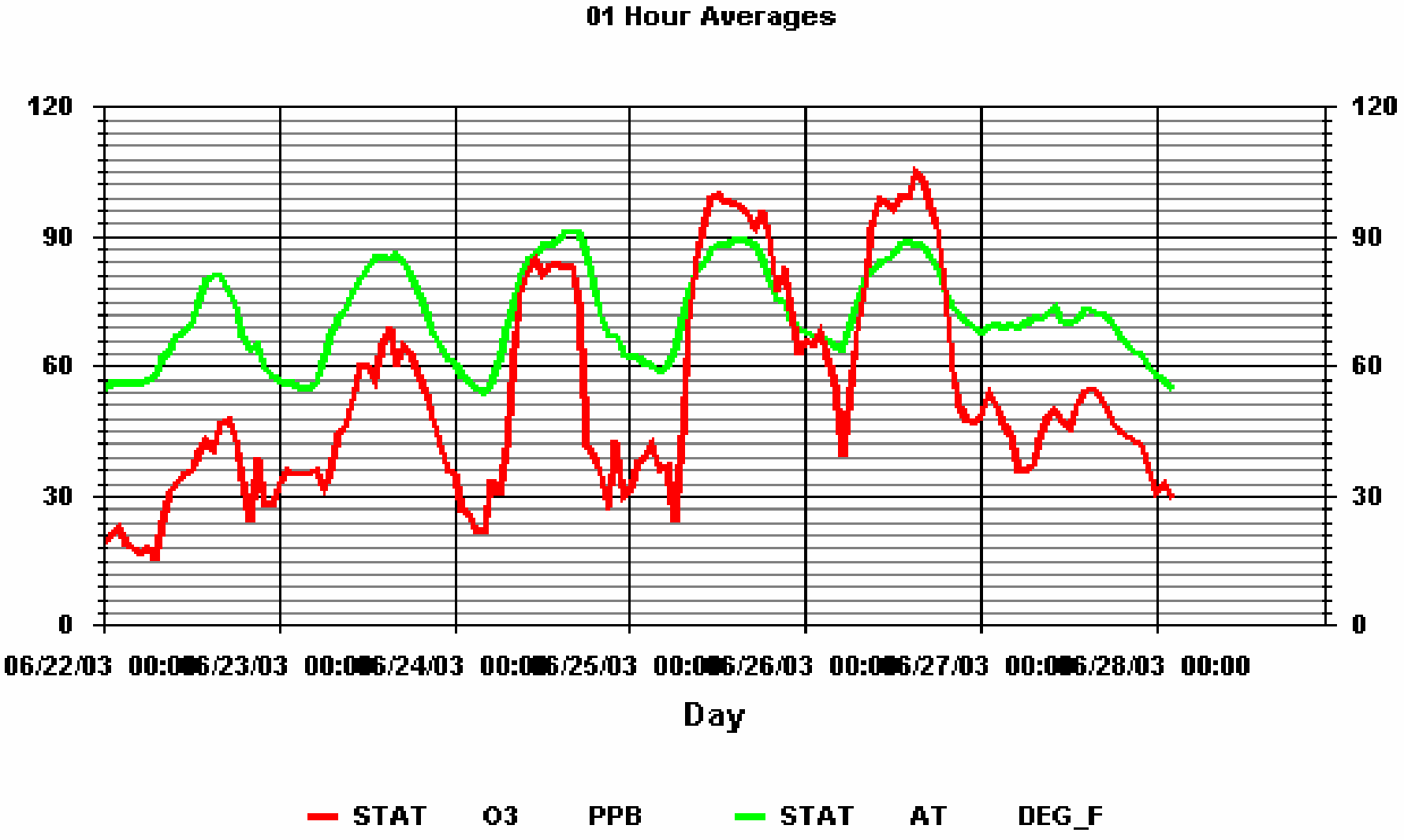
View of Nittany Mountain from Air Quality Learning and Demonstration Center: June 22, 2003 – Ozone 48 ppb



View of Nittany Mountain from Air Quality Learning and Demonstration Center: June 26, 2003 – Ozone 102 ppb

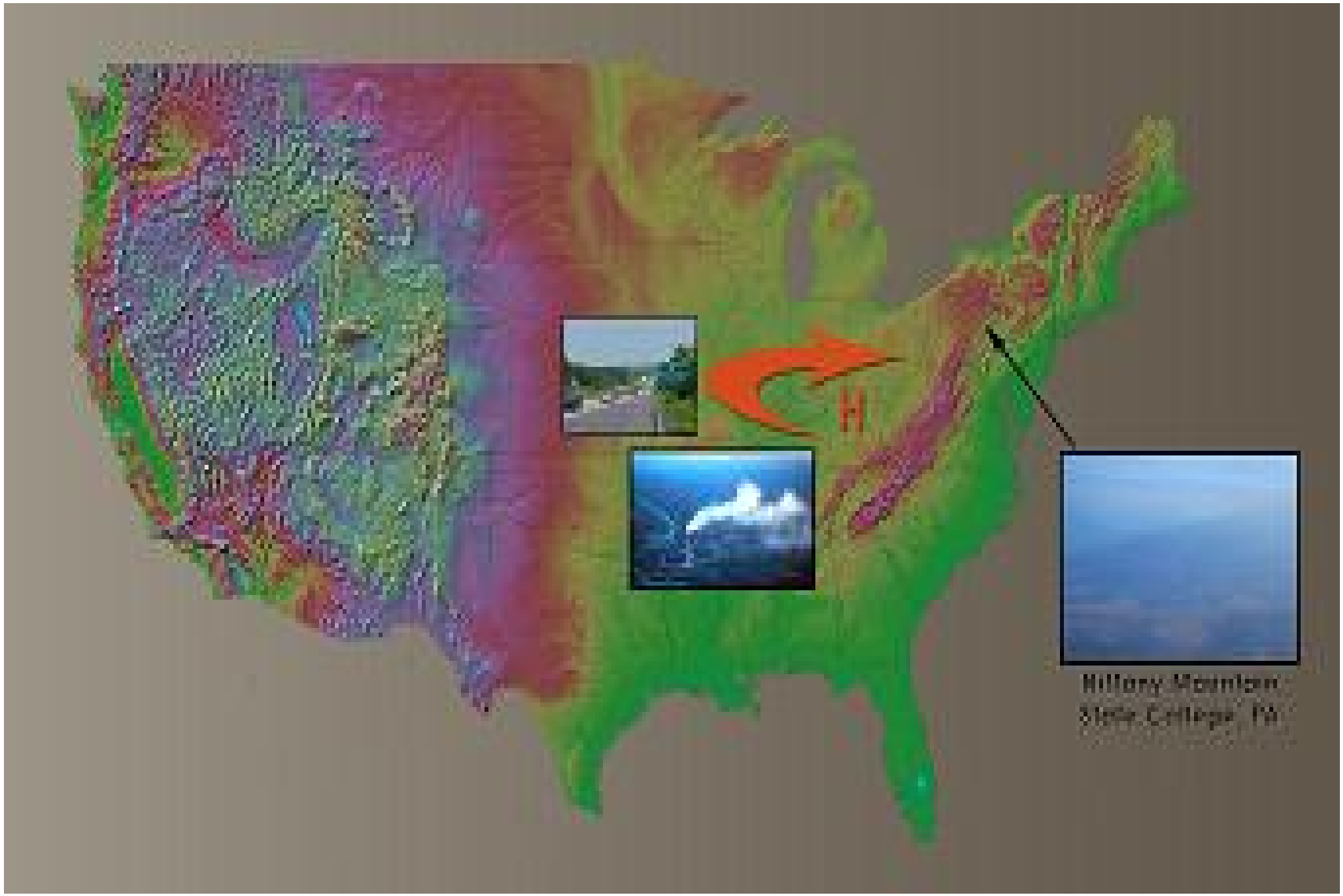


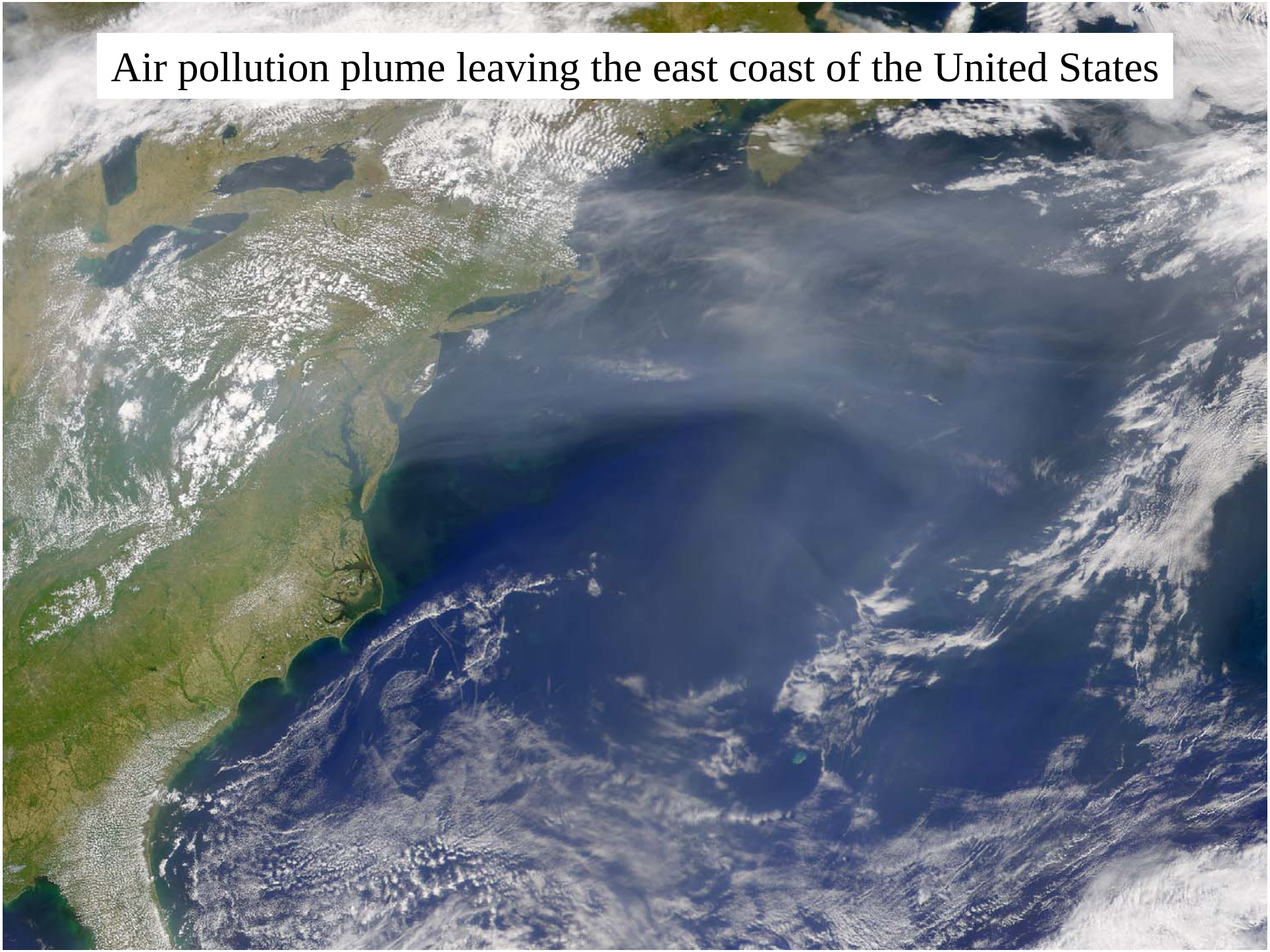
Ambient ozone concentrations and temperature during late June 2003 ozone episode in State College.



Ozone Transport in PA

- Long distance transport and buildup
- Urban/industrial areas of the west and south
- Houston, Ohio, Kansas City, Chicago, western PA
- Ozone season is April thru October.
- Stagnant high pressure systems such as Bermuda


H
Hillary Mountain
State College, PA


Air pollution plume leaving the east coast of the United States

Teaching pavilion

Sampling of Presentations

- Governor's School for Agricultural Sciences
- Agroecology class lecture and lab
- Design students from College of Architecture
- Farm Bureau
- PDA Advisory Group on Air Quality
- Community of Adult Learners class
- College of Agricultural Sciences donors
- Local high school science teachers


AIR QUALITY LEARNING
& DEMONSTRATION CENTER

Plants as Bioindicators of Air Pollutants

What is a Bioindicator?

A bioindicator is a plant that exhibits symptoms of injury when exposed to toxic concentrations of a pollutant or pollutant mixture.

Common Characteristics of a Good Bioindicator

1. Easy to recognize
2. Commonly occurring and easy to find
3. Very distinctive symptoms of injury
4. Genetic stability
5. No major insect and/or disease problems (few mimicking symptoms)
6. Known growth requirements (environmental growth conditions such as amount of light, amount of water, etc.)

To the right are examples of some common bioindicator plants grouped by responses to specific pollutants.

OZONE (O_3)



Black Cherry



Milkweed


White Ash


Yellow-Poplar


Sassafras


Dogbane


Wayfaring Tree

Sulfur Dioxide (SO_2)


Sumac


White Ash


White Pine

Hydrogen Fluoride (HF)

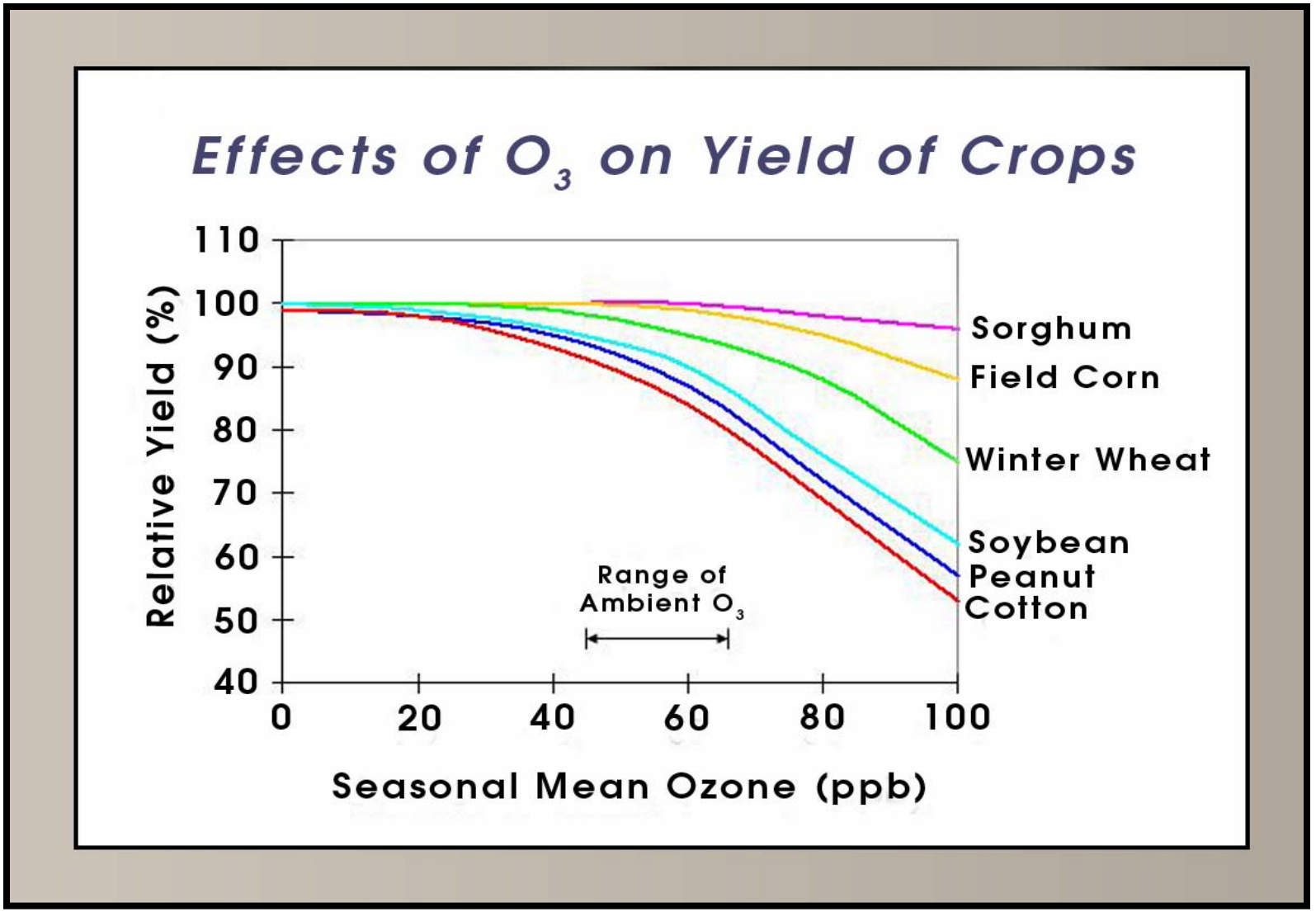

Gladiolus


Sugar Maple

PENNSTATE 1855 Air Quality Learning & Demonstration Center

THE ARBORETUM AT PENN STATE

Ag Crops


Effects of O_3 on Yield of Crops
Relative Yield (%)
110
100
90
80
70
60
50
40
0
20
40
60
80
100
Seasonal Mean Ozone (ppb)
Range of Ambient O_3
Sorghum
Field Corn
Winter Wheat
Soybean
Peanut
Cotton

Web cameras are located inside both filtered and non-filtered chambers to follow progression of growth and visible ozone injury through the entire growing season.

Filtered Chamber

Ambient Air

LaChipper 2005
Learning Center Open Tops

Full Filter Non-Filter Open

PA DEP Secretary McGinty

Energy Expo - PSU

Hey, those are our leaves!!!

Learning Center Grants

- US EPA Environmental Education Grants - Region III -
  "Enhancing Teacher Knowledge of Air Pollution Effects on Plants"
- PA DEP - "*Education and Biological Effects Research as Related to Ground-Level Ozone"*
- Reliant Energy Foundation - Grant in Aid
  "Support of General air Pollution Program at Penn State"

General Objective

- Improve teacher knowledge on effects of ground level ozone on plant health
  - In-service training workshop - designed to enhance critical thinking and data analysis on real time ozone levels and occurrence of plant injury to sensitive plants
  - Three credit summer course - air pollution effects on terrestrial ecosystems

In-service training workshop

- Designed to enhance critical thinking and data analysis on real time ozone levels and occurrence of plant injury to sensitive plants
  - Morning - background information on the major pollutants and ozone symptoms on plants
  - Afternoon - learning exercise that uses analyses of archived pictures and meteorological data
    - Picture archive of progression of symptoms developed during summer of 05
    - After teachers are trained to use data sets, they will be able to access data through learning center website during school year for use in classroom lab

Filtered

Non-Filtered

The common milkweed was the plant chosen for monitoring for injury since it is relatively abundant and shows very distinct injury symptoms.

- A previous picture of zone injury (somewhat severe) on common milkweed. Upper leaf surface stipple, not on lower leaf surface, and not crossing leaf veins.

Examples of images captured during the summer of 2005

- Picture of milkweed in the carbon-filtered chamber (left) and non-filtered chamber (right) observed on September 8, 2005

Three credit summer course - air pollution effects on terrestrial ecosystems

- Primary audience k-12 science teachers initially primarily in central PA
- 3 week summer course
  - Overview of the effects of air pollutants on terrestrial plants and ecosystems
  - Current air pollution-related issues discussed
  - Special attention at using hands-on projects that could be accomplished in the high school classroom
  - All day field trip to power plant

Benefits to public school science teachers

- Satisfy professional development requirements for maintaining a PA professional education certificate as mandated by ACT 48
- Enhance science curriculums to help satisfy PA Dep. of Education Academic Standards for the Environment and Ecology
  - 4.3 Environmental Health
  - 4.6 Ecosystems and their Interactions
  - 4.8 Humans and the Environment
  - 4.9 Envirnmental Laws and Regulations

Benefits to public school science teachers

- To help defray tuition costs for enrolled teachers, up to twelve scholarships of $500 would be awarded on a competitive basis

Bean - Regional Study

Bean - Multiple Marketable Pod Harvest

Results are from 10 plants per plot (4 reps per cultivar)

		Early Mkt (1st harvest)		Total Mkt (3 harvests)	
Cultivar		wgt (g)	pods (#)	wgt (g)	pods (#)
6/8/04 planting					
S156	470.7	113.5		701.8	168.0
R331	471.4	96.0		1219.3	206.2
7/26/04 planting					
S156	92.8	35.8		474.7	139.9
R331	60.3	24.8		555.7	132.3

Bean - Final Biological Harvest

Results are from 10 plants per plot (4 reps per cultivar)

		Total Pod				Total Seeds		
	Hvst Date	Dry pods (no.)				Dry		
Cv		wgt (g)	w/seeds	wo/seeds	total	wgt (g)	no.	ave.wgt (g)
6/8/04 planting								
S156	9/1	89.3	100.8	17.0	117.8	63.4	312.0	0.203
R331	9/14	227.8	140.0	1.3	141.3	173.0	561.5	0.308
7/26/04 planting								
S156	10/4	41.5			85.3			
R331	10/4	227.8			114.8			

Ambient Ozone Effects on Wine Grape Production in Pennsylvania

PA Wine Facts

- Pennsylvania's moderate climate and rolling terrain provides some of the best growing conditions on the east coast. Here, more than 90 wineries produce a delightful array of wine varieties - perhaps more kinds than any other wine region.
- The roster of award-winning Pennsylvania varietals includes: Cabernet Sauvignon, Catawba, Cayuga, Chambourcin, Chardonnay, Gewurztraminer, Pinot Gris, Pinot Noir, Reisling, Seyval Blanc, Vidal Blanc, Vignoles - and, yes, even wine made in the Champagne manner!

http://www.pennsylvaniawine.com/facts/index.asp

PA Wine Facts

- With approximately 14,000 acres of grapes, Pennsylvania ranks 4th nationally in the amount of grapes grown (including juice grapes). The state also ranks 8th in the production of wine.
- Pennsylvania is home to the two highest elevation vineyards east of the Rockies
- The nation's first commercial grapevine nursery was in Montgomery County in SE PA

http://www.pennsylvaniawine.com/facts/index.asp

History of ozone injury on grapes in the northeast

- Ozone injury within eastern North American vineyards was first reported in 1972 at the New York Agricultural Experiment Station at Geneva.
  - They had documented ozone injury as early as 1966 on the foliage of several American and French hybrid grape varieties within the grape-growing regions of New York and southern Ontario.
  - “Chambourcin” was listed as being among the more sensitive French hybrid varieties. Currently, this variety is rapidly becoming the most important red wine variety in Pennsylvania and New York.

History of ozone injury on grapes in the northeast

- our unpublished field observations and ozone-chamber studies have revealed that Chambourcin is likely even more sensitive to ambient ozone than was indicated by the early studies at Geneva.
- We have observed significant ozone injury on Chambourcin grapes at several locations within Pennsylvania's grape growing regions, observations that clearly demonstrate significant ozone injury on this variety.

Importance of Chambourcin

- Chambourcin is a French hybrid with great potential for making high quality wines.
- Its attributes include phylloxera tolerance, winter hardiness and somewhat greater resistance to common fungal diseases.
- It is currently being widely planted in Pennsylvania and New York.
- As an alternative to European red grape varieties, Chambourcin can make comparable quality wine

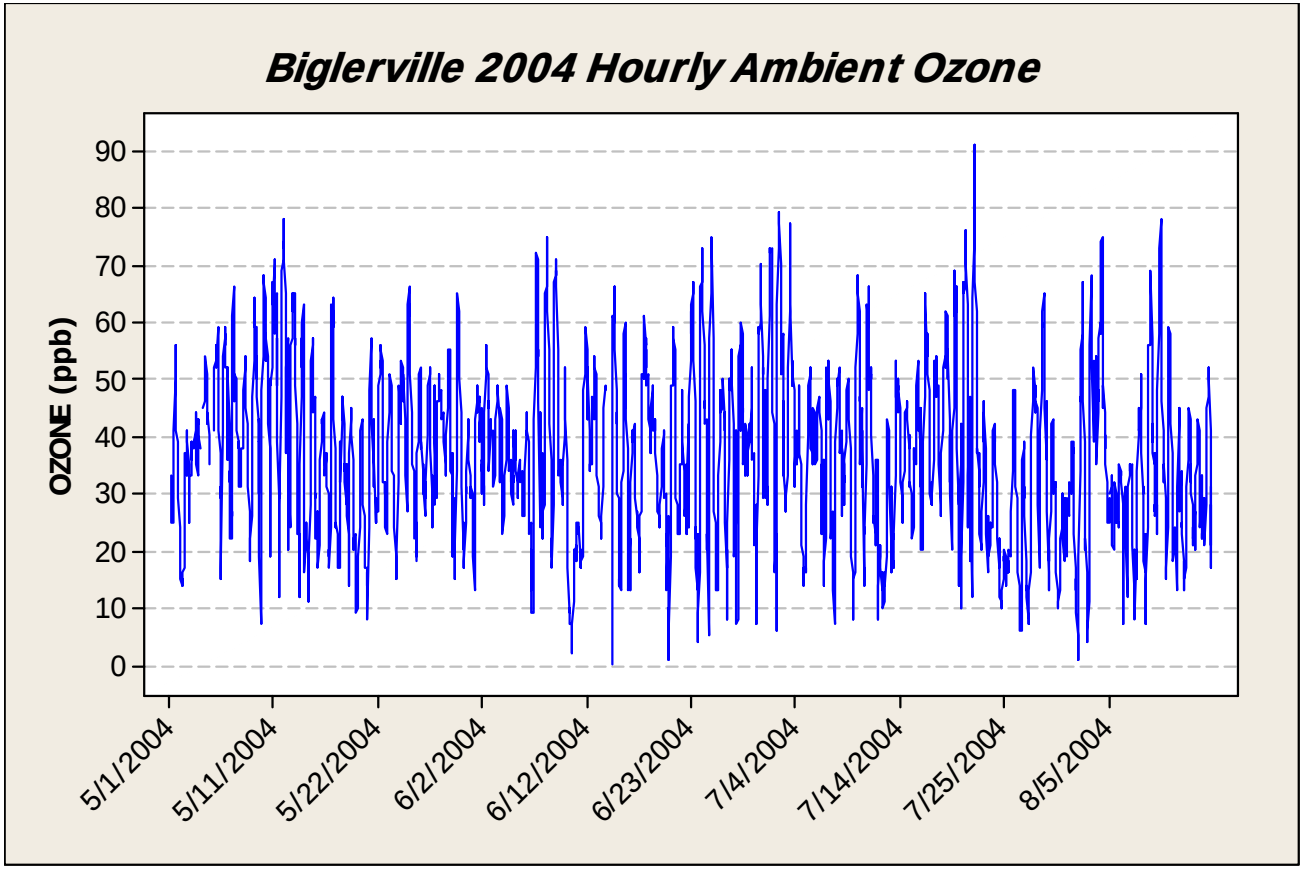
Ozone Chambourcin Grape Project - Biglerville, PA

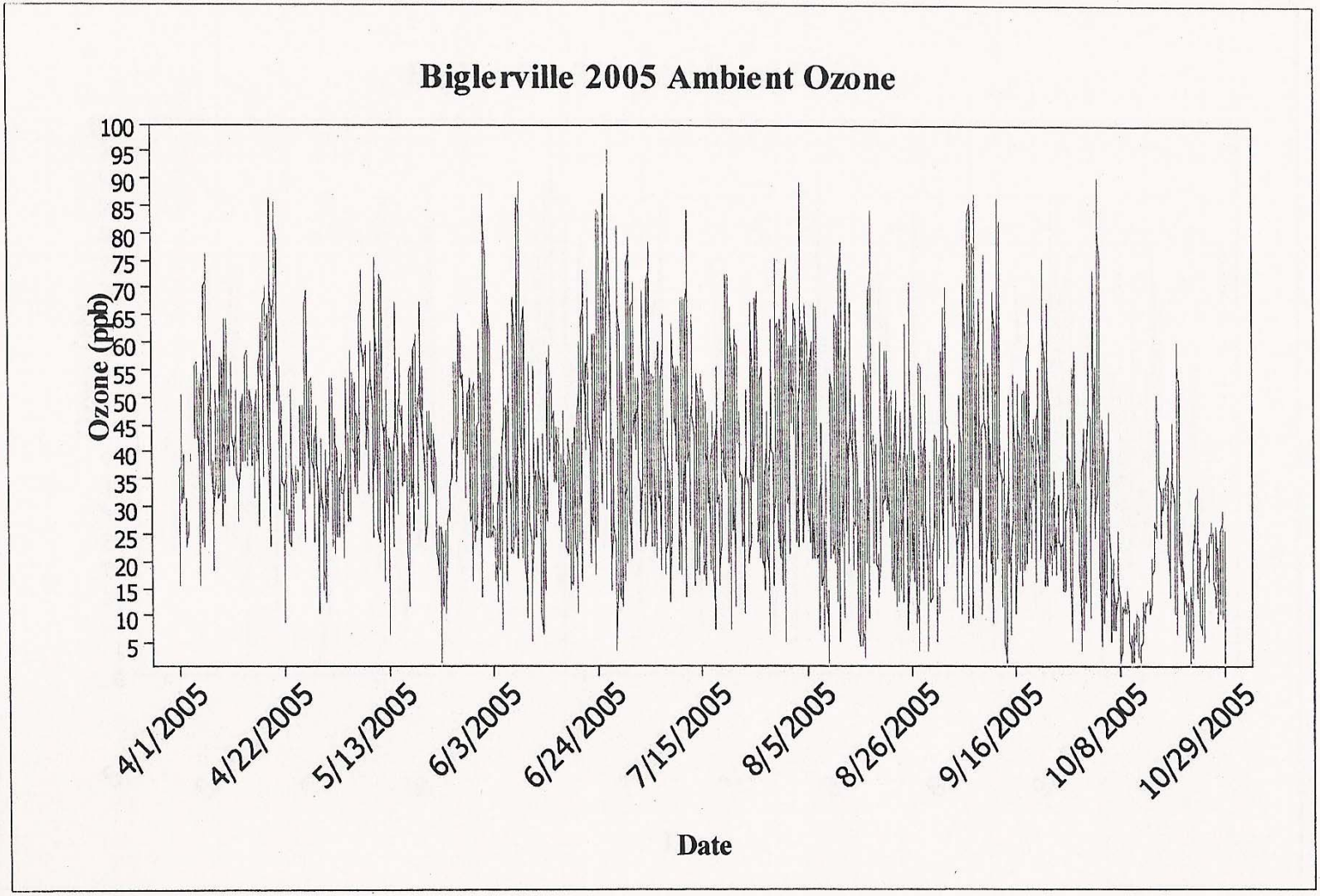
Ozone symptoms

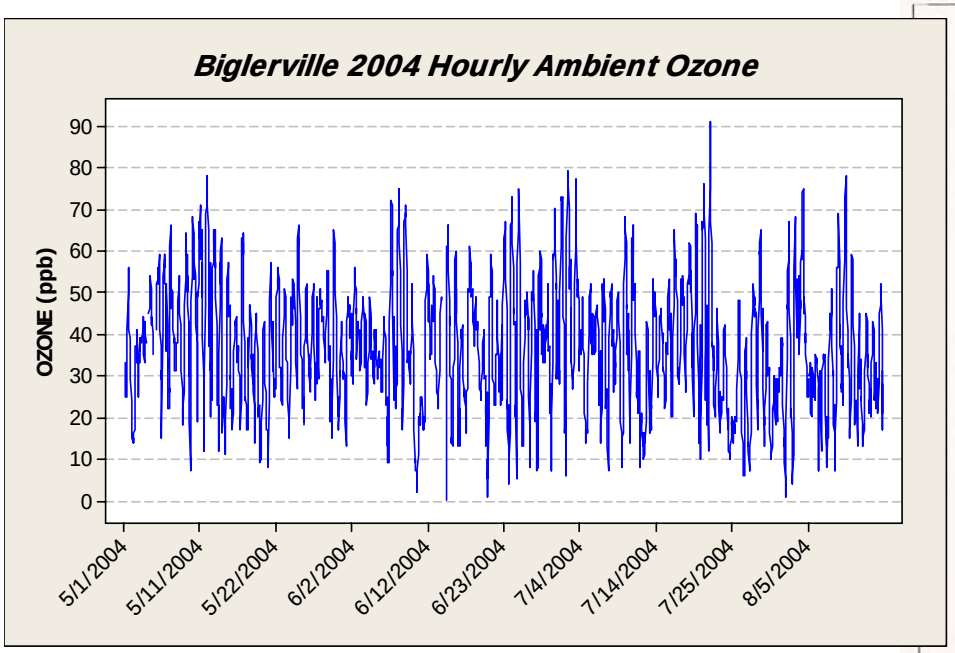
Bounty peach

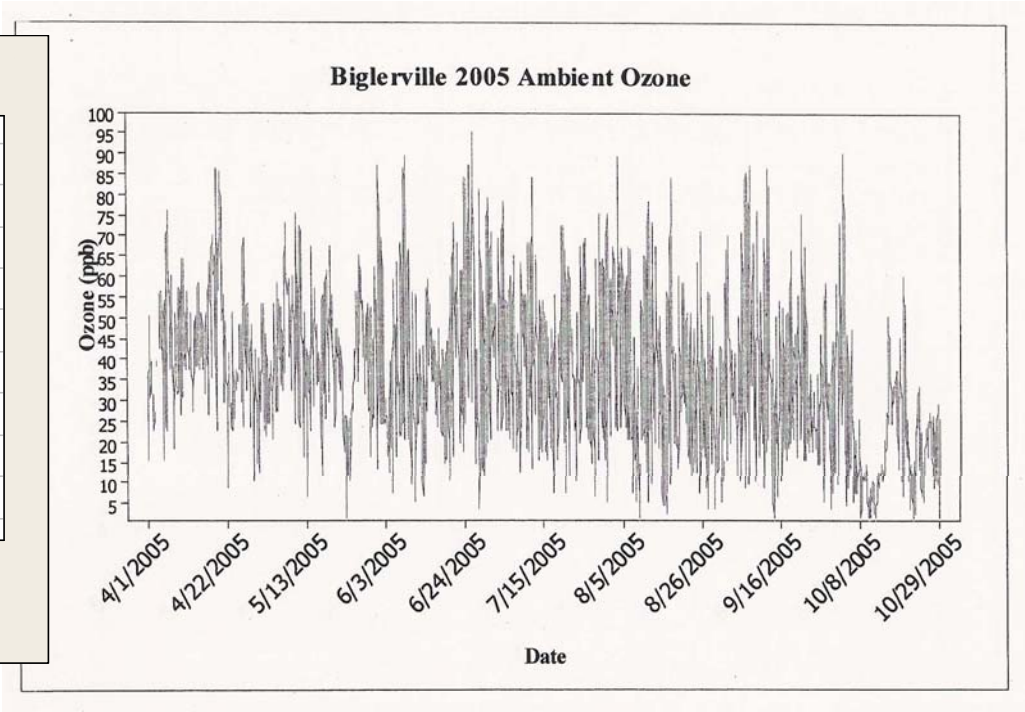
Peach foliar injury

Ambient hourly ozone concentrations from 5/1/04 to 8/15/04. Sensitive plants exposed to repeated exposure above 60 to 70 ppb will exhibit injury.




Biglerville 2005 Ambient Ozone
Ozone (ppb)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
4/1/2005
4/22/2005
5/13/2005
6/3/2005
6/24/2005
7/15/2005
8/5/2005
8/26/2005
9/16/2005
10/8/2005
10/29/2005
Date


Biglerville 2004 Hourly Ambient Ozone
OZONE (ppb)
0
10
20
30
40
50
60
70
80
90
5/1/2004
5/11/2004
5/22/2004
6/2/2004
6/12/2004
6/23/2004
7/4/2004
7/14/2004
7/25/2004
8/5/2004


Biglerville 2005 Ambient Ozone
Ozone (ppb)
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
4/1/2005
4/22/2005
5/13/2005
6/3/2005
6/24/2005
7/15/2005
8/5/2005
8/26/2005
9/16/2005
10/8/2005
10/29/2005
Date

Mean, maximum, and date of maximum hourly ambient ozone concentrations for Biglerville, PA

2004
Month

	May	June	July	Aug	Sept
Mean	38	37	36	34	29
Max	78	75	91	78	76
Date of Max	5/12	6/8	7/22	8/10	9/23

2005
Month

	May	June	July	Aug	Sept
Mean	41	39	40	36	36
Max	75	95	84	89	87
Date of Max	5/10	6/26	7/12	8/4	9/8

OZONE LEVELS IN 2004 AVERAGE RECORD LOW

COMMONWEALTH OF PENNSYLVANIA
Department of Environmental Protection
Commonwealth News Bureau
Room 308, Main Capitol Building
Harrisburg, PA 17120

FOR IMMEDIATE RELEASE
9/27/2004

HARRISBURG: Environmental Protection Secretary Kathleen A. McGinty today announced that Pennsylvania experienced historically low ozone concentrations this summer as unusually cool, damp weather helped to drive down the number of ozone action days from May to mid-September.

DEP monitors registered 13 days that exceeded the eight-hour ozone standard, the lowest number in the last 10 years. No state monitors exceeded the one-hour ozone standard.

Open top chamber field site

2004 Season

Last rating (9/7/04)

	% leaves injured		%injury on injured leaves	
Treatment	Chambourcin	Vidal	Chambourcin	Vidal
Open plot	22.06 ± 3.22	2.00 ± 0.58	5.25 ± 0.75	1.50 ± 0.50
Non-Filtered	17.42 ± 1.93	0	6.00 ± 1.11	0
Filtered	1.46 ± 0.31	0	0.85 ± 0.10	0

ANOVA

	Probability	
Source	% leaves injured	%injury on injured leaves
Block	ns	ns
Trt	**	**
Block * Trt	ns	ns
Cultivar (Trt)	***	**

2005 Season

last rating (10/20/05)

	% leaves injured		%injury on injured leaves	
Treatment	Chambourcin	Vidal	Chambourcin	Vidal
Open plot	8.13 ± 1.38	1.00 ± 0.71	4.44 ± 0.68	1.00 ± 0.71
Non-Filtered	5.36 ± 0.64	0	3.07 ± 0.27	0
Filtered	0.77 ± 0.36	0	0.31 ± 0.13	0

ANOVA

	Probability	
Source	% leaves injured	%injury on injured leaves
Block	ns	ns
Trt	**	***
Block * Trt	ns	ns
Cultivar (Trt)	***	***

Effects on juice quality

Data from Dr. Jim Travis

Juice Data (both cultivars)

2004 Season

	Open	Non Filt	Filtered	Prob	Trend (F vs NF)
Weight/100 berries (g)	196.8	203.8	217.4	0.019	
PH	3.30	3.43	3.43	0.066	–
Brix	20.33	21.36	21.66	0.218	↑
Tot Acid	9.55	7.58	7.84	0.001	↑

2005 Season

	Open	Non Filt	Filtered	Prob	Trend (F vs NF)
Weight/100 berries (g)	187.9	199.6	204.4	0.107	↑
PH	3.14	3.20	3.14	0.028	↓
Brix	19.19	21.98	21.37	0.001	↓
Tot Acid	9.16	8.06	8.44	?	↑

Juice Data (Chambourcin only)

2004 Season

	Open	Non Filt	Filtered	Trend (F vs NF)
Weight/100 berries (g)	232.7	235.9	257.8	↑
PH	3.27	3.38	3.38	–
Brix	19.25	20.10	20.68	↑
Tot Acid	10.40	8.78	8.74	–

2005 Season

	Open	Non Filt	Filtered	Trend (F vs NF)
Weight/100 berries (g)	207.2	217.1	225.4	↑
PH	3.10	3.08	3.07	–
Brix	18.61	21.24	20.61	↓
Tot Acid	9.88	8.93	9.58	↑

Juice Data (Vidal only)

2004 Season

	Open	Non Filt	Filtered	Trend (F vs NF)
Weight/100 berries (g)	160.8	171.7	177.0	↑
PH	3.35	3.49	3.48	–
Brix	21.40	22.63	22.65	–
Tot Acid	8.70	6.38	6.94	↑

2005 Season

	Open	Non Filt	Filtered	Trend (F vs NF)
Weight/100 berries (g)	149.3	164.6	162.3	–
PH	3.24	3.45	3.31	↓
Brix	20.35	23.45	22.88	↓
Tot Acid	7.73	6.34	6.15	↓

Effects on berry and foliage diseases

Ripe rot

Powdery Mildew

Powdery Mildew

Ozone

2005 Season – Percent Incidence of Disease

	Open	Non Filt	Filtered	Trend (F vs NF)
Chambourcin				
Clusters				
Ripe Rot	25.83	29.00	22.50	↓
P. Mildew	3.34	1.67	0.00	–
Shoots				
P. Mildew	35.00	42.50	0.00	↓
Ozone	93.35	100.0	54.17	↓
Vidal				
Clusters				
Ripe Rot	35.00	42.50	10.00	↓
P. Mildew	0.00	0.00	0.00	–
Shoots				
P. Mildew	85.00	75.00	60.00	↓
Ozone	20.00	20.00	0.00	↓

2005 Season – Percent Severity of Disease

	Open	Non Filt	Filtered	Trend (F vs NF)
Chambourcin				
Clusters				
Ripe Rot	3.00	1.57	1.02	↓
P. Mildew	0.08	0.04	0.00	–
Shoots				
P. Mildew	4.32	11.14	2.48	↓
Ozone	8.83	10.83	2.62	↓
Vidal				
Clusters				
Ripe Rot	2.23	1.28	0.30	↓
P. Mildew	0.00	0.00	0.00	–
Shoots				
P. Mildew	2.81	4.80	2.81	↓
Ozone	0.70	0.47	0.00	↓

Spent mushroom compost mulch evaluation

Grape Conclusions

- Preliminary results indicate that ambient ozone occurs in sufficient concentrations in Pennsylvania to cause foliar injury to sensitive grape varieties (such as Chambourcin).
- These observations were verified when plants were exposed to carbon-filtered air (that reduced ozone concentration by about 50%). These plants exhibited only a trace of ozone injury.
- Little information is known regarding ozone exposure levels needed to cause injury and long term impacts on the health of the plant.
- The effect of ozone-induced foliar injury to Chambourcin on grape fruit quality is not known and is under current investigation.

Future?

- Results might be more impressive if we had a “typical” ozone year
- Yield/berry (quantity and quality) effects still need to be sorted out
- Survey of extent of damage needed
- Extensive taste testing needed

Websites for Further Information

- Lab Website http://www.aireffects.psu.edu/
- Learning Center Websites - http://www.aireffects.psu.edu/learning/index.htm


Many thanks for your attention and interest
Questions?
and finally…
The End