How Does Temperature Affect the Success Rate of a Wood Duck's (*Aix sponsa*) Nest?

(001064-015)

Word Count: 3,626

Crystal Kozlak

2/15/2012

Table of Contents:

Abstract:

Global warming affects many areas of the world, including many species, like the wood duck (*Aix sponsa*). This North American duck migrates to northern climates in spring to lay their eggs before they migrate to the south for the winter. The increasing temperature of the globe could seriously affect the number of wood duck eggs hatched, thus reducing the general wood duck population. This field experiment tested if a warmer temperature had an impact on the number of wood duck eggs hatched. In the Hazel Wolf Wetlands Preserve, Sammamish, Washington, United States, temperature probes were installed into wood nesting boxes. These temperature probes measured the temperature every hour from March 25, 2011 to June 6, 2011. There were 13 nesting boxes in total, 8 boxes were installed with temperature probes, only 5 probes were found at the end of the experiment when the data was collected, and observed, in October. After the nesting period, as a result, the number of egg shrouds and dead eggs were counted, as well as small observations were noted. The raw data from the temperature probe data was compared to the observations that were made in the lab. When the data and the observations were compared, there happened to be an inverse correlation between an increase of temperature and success rate of wood ducks' egg hatching. As the temperature increased, there were fewer eggs that hatched. Although, there could be many factors as to why a wood duck nest might not be successful, the nests which were exposed to more of an increase of temperature had more rotten eggs by the end of the spring.

Introduction:
How does temperature affect the success rate of a wood duck's (*Aix sponsa*) nest?

Sammamish, Washington, USA has weather that changes frequently which might seriously affect the population of wood ducks. The Wood Duck (*Aix sponsa*) is a beautiful, unique bird that, unlike most waterfowl, will place their nest inside a tree cavity instead of building their own nest (Kortright, 1943). See figure one for the exterior characteristics of a female wood duck, and figure two for the exterior characteristics of a male wood duck.

Figure 1: The female wood duck has brown feathers, and a white tear drop over her eye

Figure 2: The male wood duck has a variety of different colored feathers, and like the female wood duck, he has a round head

Wood ducks fly to northern climates, like Washington to lay their eggs during early spring, when weather is still cool. The eggs are subsequently hatched in late spring, usually when Washington has a fairly warmer temperature. Although wood ducks continue to fly north to lay eggs, global warming has became a huge concern to the bird population. 2011 was the ninth hottest year on record (Painting, 2012). The increase of green house gases has caused an increase of global temperature, and the overall ocean temperature (Painting, 2012). Figure three demonstrates the increase of temperature from 1880 to 2011.

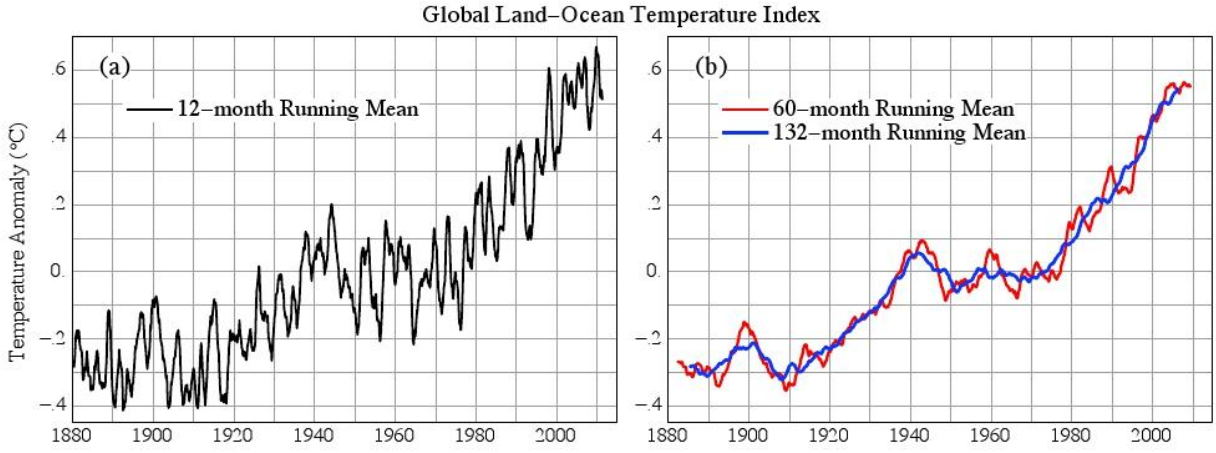


Figure 3: The increase of temperature from 1880 to 2011

As global temperature increases, spring occurs earlier each year (Hance, 2012). When spring occurs earlier, ducks then migrate north earlier for nesting thus missing out on the best feeding days in the south (Hance, 2012). This has the potential to ruin their nesting times (Hance, 2012). This increase of temperature could seriously impact the success rate of a wood duck's nesting period.

During the nesting season, the wood duck selects an area in the northern United States and Canada (Davis, 2012). In nature, wood ducks rely on woodpeckers to carve a hole in a decaying tree as their nest. In early spring, the female wood ducks will search for these tree cavities in the wetlands (Burris, 2010). The hole does not have to be very big for an adult wood duck to enter. A female wood duck is about 0.57 kg (+/-.01 kg) and 45.72 cm (+/- .01 cm) long and she can fit through a hole that is about eight by ten centimeters in diameter (Kortright, 1943). This type of waterfowl tends to choose a wetland in a wooded or a heavily vegetated area because then there are plenty of tree cavities available to them (Erickson, 1974).

A hen has to find a perfect spot in order to nest, a spot with the highest survival rate for her ducklings. For instance, a location close to waters is perfect because day old ducklings are capable of swimming and diving, and being near the water, there is less likely chance of encountering predators (Hester and Dermid, 1973). However, animals like beavers tend to cause problems to wood ducks. Beavers can gnaw through trees that contain nests or nest boxes. Raccoons, which are one of the biggest threats to the wood ducks, regardless of location are aggressive (Hester and Dermid, 1973). This predator will eat the wood duck eggs in the nest before they are even hatched, if the hole is big enough for them (Hester and Dermid, 1973).

With many predators, the female wood duck must be able to find a safe environment for her ducklings, which a wooded area with plenty of food. In the Northwest wetlands like in Sammamish, Washington, USA, there is a great source of nourishment like wild rice, duck weeds, cones, grasses, water lilies, and bugs (Kortright, 1943). Regardless of the perfect area that the female wood duck chooses, there are some serious, outside dangers. One of these dangers is the influence of humans. One example of this is hunting. During each hunting season 9% of the wood duck population is shot (Kirby 1989). In 2000 and 2001, about 1.2 million wood ducks were hunted (Davis, 2012). Hunting greatly effects the wood duck population.

Hunting may be a problem to the wood ducks, but one must also consider nest dumping. Nest dumping is when another species or the same species of bird will dump their eggs in the nesting cavity and will not return to hatch the eggs (Burris, 2010). If this occurs, other wood ducks will either dump their eggs or avoid laying their eggs there. This could greatly impact the number of wood ducks hatched. If other birds are nest dumping their eggs than no birds will be able to use that nesting box, which would result in the lack of occupied nest boxes.

Wood ducks are willing to occupy a human made nest box instead of relying on other species, but only if the nest box suits all the requirements of an eight by ten cm hold and at least 1.5 m above the ground (Hester and Dermid, 1973). View figure four for an image of a nesting box.

Figure 4: An example of a wood duck nesting box

Inside the nesting box there is small metal grate located on the same side as the hole; this allows the day old ducklings to climb out of the nest box to fly (Burris, 2010). Humans provide wood shavings inside the box which the wood duck uses to lay her eggs. Wood ducks are most likely willing to use human made box, which is why many are installed in local communities around Northern United States, and Canada.

In the city of Sammamish, WA, USA, there have been 13 wood duck nest boxes installed in the Hazel Wolf Wetlands. The nest boxes were set up to make the female wood duck's job, finding a location for nesting, much easier. It is important for humans to use the nest boxes to observe how many ducklings are hatched each year because a decrease in population might have a correlation with global warming.

Figure 5: The Hazel Wolf Wetlands Persevere

There may be many reasons why there could be less hatching each year. Ted Burris, a man who studies wood ducks at the Hazelwolf Wetlands, said that on average, a female wood duck incubates about 9-15 eggs (Burris, 2010) It is important to know the cause of unsuccessful nests because this may be because of the increase of temperature. If a nest contains about 9-15 eggs by the end of spring, this meant that the nest was unsuccessful. A successful nest consists of a ton of down in the nest, and little to no eggs left in the nest. Nest dumping is still a common occurrence, and could impact the success rate of a wood duck's nest, but if a nest box is vacant, a hen will lay her eggs.

In order to prepare for her eggs to be hatched successfully, a female hen will pluck her feathers from her breast plate, and use these feathers as down for her ducklings (Burris, 2010). Then her breast plate will then be used to warm and incubate all her eggs. The hen will also turn the eggs to completely make sure each angle was warm prior to hatching (Burris, 2010). Although, external warmer temperature might alter the normal process that a female wood duck has to go through to incubate her eggs.

It is essential to observe the wood ducks, and the success of their nests. The causation of fewer eggs might be from the increase of temperature, which could severely harm the wood duck population. Thus, does a warmer temperature affect the success rate of wood duck eggs hatched?

A hypothesis of this experiment is, if the temperature inside the nesting box is much warmer than increasing temperature outside, then the wood ducks would produce more offspring because wood ducks try and keep their eggs warm during incubation, but if the temperature was much warmer than it might be possible for the hen to keep the eggs warm because the outside temperature would be warmer, and the hen would have to make less effort to keep her eggs warm.

Materials and Methods:

The wood ducks were observed at the Hazel Wolf Wetland Preserve just off of Windsor Dr SE Sammamish, WA, USA. There were a total of 13 nesting boxes that were set up within the wetland area. During the fall of 2010 each box was filled with wood shavings for the wood duck to use in the spring. The boxes itself had the appropriate entrance hole and was camouflage on the outside. Each box had a side door which could be unscrewed in order to change the bedding and collect eggs. The nesting boxes were installed prior to the experiment among the trees around the perimeter of the wetland, in slightly different locations. Some boxes were closer to the banks of the open waters (pond) and others are placed further away in the trees or closer to the hiking trail.

In order to obtain quantitative data before the wood ducks started laying eggs, the temperature probes were installed before the spring began. A total of eight temperature probes were installed on the inside various nesting boxes. The probes had a Velcro sticker that when installed, the sticker would attach to the side wall of each of the nesting boxes. Each probe was set to record the temperature every hour. The temperature probe recorded the temperature every hour from March 25, 2011 to June 5, 2011. In order to install the temperature probes, the researcher climbed a ladder to each nesting box and unscrewed the side of the door, then attached the temperature probe on the inside of the door. The temperature probes were collected on June 5, 2011, and the raw data was uploaded from the device to the computer. This data was then processed, and formatted in a more condensed table for each box. The table was processed so that the minimum, maximum, and average temperature for each day was formatted in a table for each temperature probe. These tables were processed into graphs, and then compared to the qualitative data.

The egg laying data was more complex to obtain, as it could only be obtained after the wood duck had finished nesting. In the fall of 2011, after the wood ducks were finished nesting and already migrated south for the winter, each nest was cleaned out in order to observe how many eggs were hatched. This was done by returning to the nesting boxes, and sliding a thin metal sheet underneath the used bedding, carefully pulling out the used bedding in the same shape as it was inside the nesting box. A small cardboard box without a lid and the sides cut off so that the used bedding could slide right into the cardboard box. Finally, the cut edges of the box were resealed to preserve the materials so they are observed later in the lab. The box was labeled to match the corresponding box number. Although, some of the nesting boxes did not have a number, or a visible number, the cardboard box was labeled with a description of where the nesting box was located.

At Skyline High School, the used nest bedding was analyzed by pulling the bedding apart layer by layer, saving any eggs that were found, counting the number of egg shrouds/shells, and throwing away the old bedding after the observation. See figure six for a picture of the wood shavings being taken out of the nesting box. Observations were made during the process, and written down, as was a count of the number of eggs that were found was recorded.

Figure 6: Demonstration of the wood shavings being taken out of the nesting box

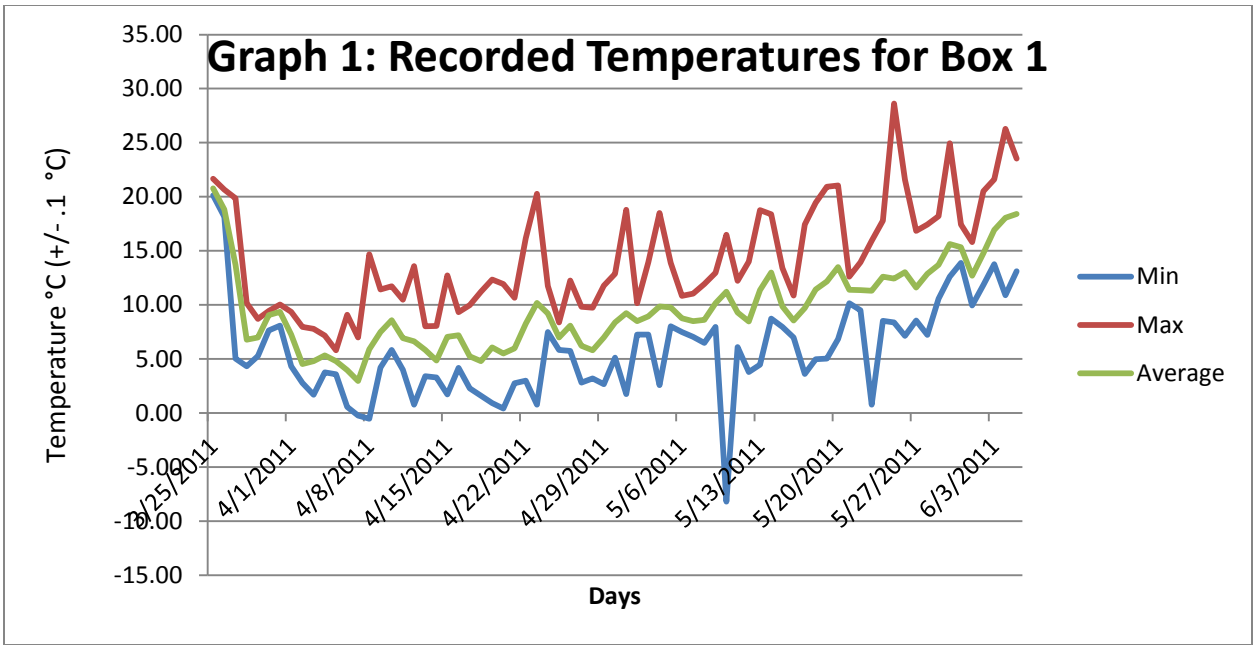
Data Collection:

The temperature probes, which were installed in eight of the boxes, took the temperature (in Celsius) of the inside of the box every hour. Only five of the eight temperature probes which were installed, were found. The initial raw data was then processed into a condensed data table that showed the average, minimum, and maximum temperature for each day, between March 25, 2011 to June 5, 2011. The minimum temperature most likely represents a temperature during the night, and the maximum temperature most likely represents the middle of the day, while the average temperature is in between both temperatures.

Because the processed data tables were too long (appendix), the data in the tables were placed in a graph which shows the temperature changing over time. This process was done for each box. The beginning and end of each graph (where each line begins around 20 degrees Celsius) is where the temperature probe measured the room temperature, before and after being placed in the nesting box.

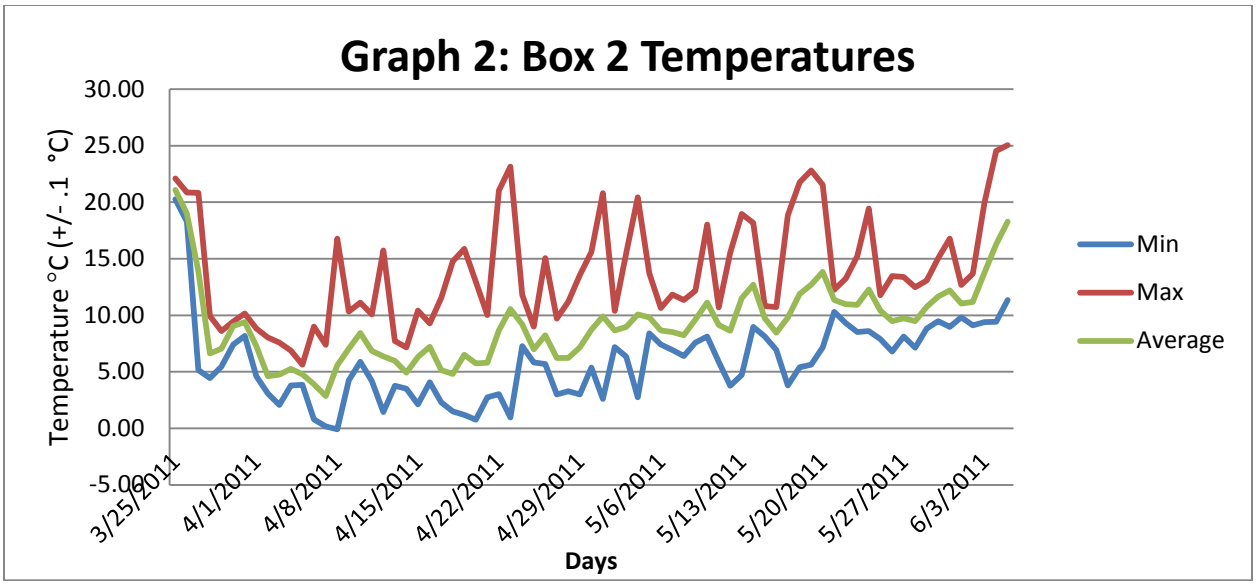
Finally, there are recorded observations for each of the nest boxes. The nests were divided into three layers for observation. The nests were divided into three layers to find the complete history of that nesting box over the two to three months that the temperature probes were installed. The nesting boxes with egg shrouds meant that the nest did have a successful hatch. The nests that still contained eggs meant the hatching was unsuccessful. Especially, if there were another species' eggs, this meant there was a nest dump in that box. There was noted anything else that might have been unusual in the nest because this might have contributed to the result of the hatchings.

What follows are the qualitative and quantitative data, and analysis for the recorded temperature probes for nesting boxes 1,2,4,6, and 12.



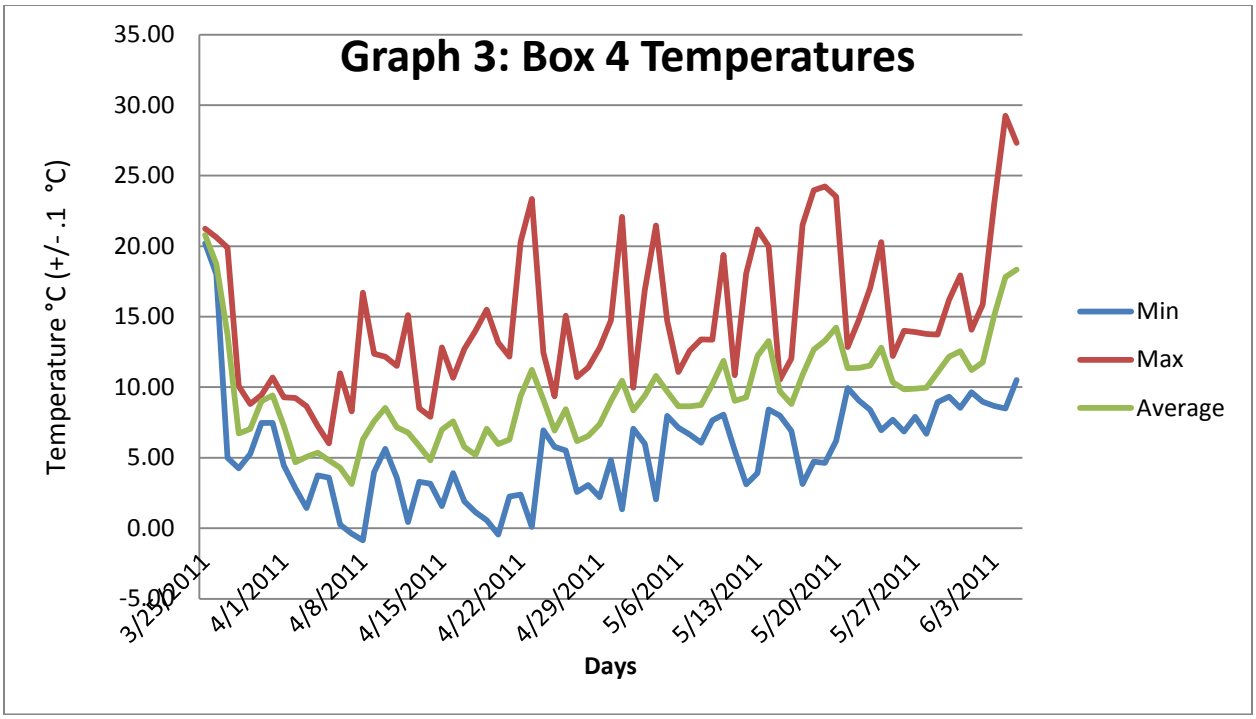
Box 1: There was a lot of shrouds, and down feathers. The down was near the center of the nest. There were many cracked eggs on the third level, but not as much down. One of the eggs that was not hatched had yolk coming out of it. There as a block of wood, leaves, and a piece of camouflage. Finally, small bugs at the bottom of the nest with some chrysalis. The nest was a success.

Analysis: As seen in graph 1, the average temperature increased from 6.0°C to 16.0°C over the course of this experiment. The temperatures between the days fluctuated, especially the maximum temperature. The maximum temperature peaked to a high point of 28.0°C on 5/26/2011. The minimum temperature decreased as far as -7.0°C on 5/13/2011. This nesting box had general increase of temperature, despite some temperature increasing or decreasing, and yet the nest was successful.



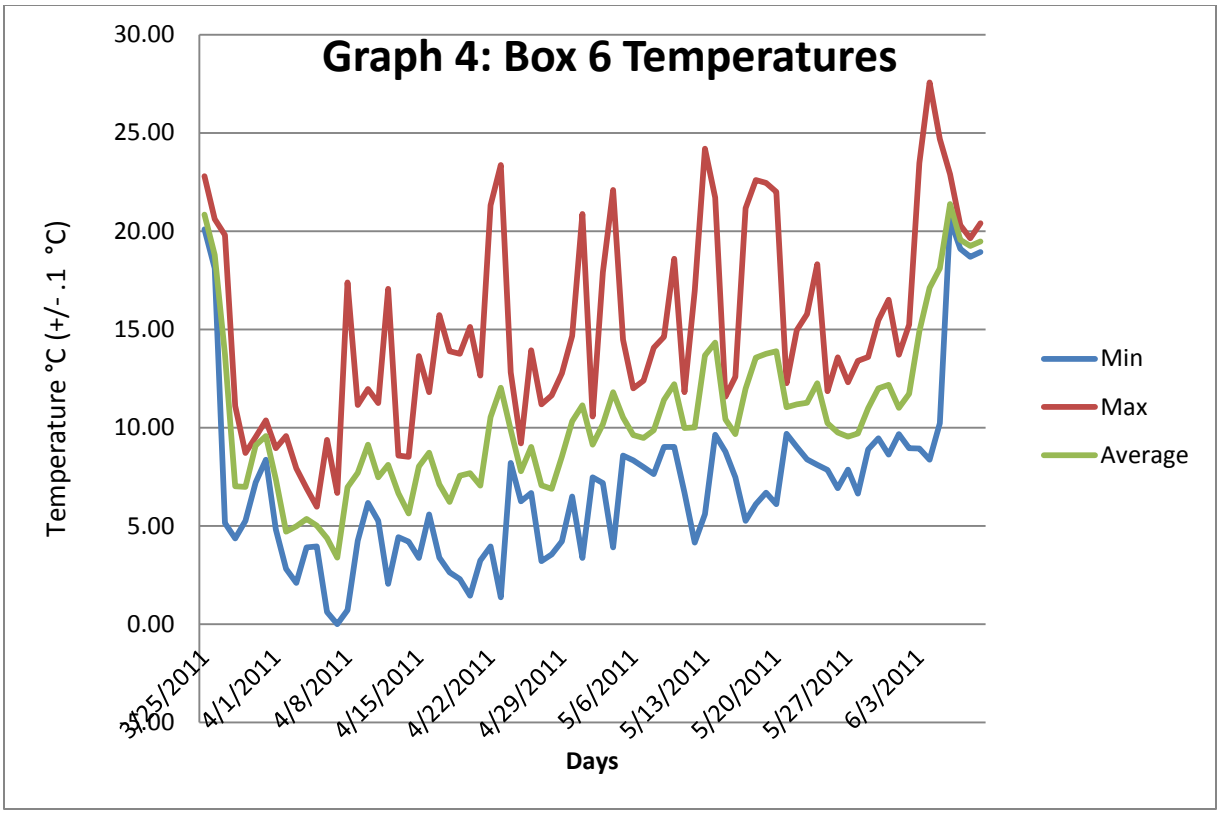
Box 2: There were long feathers and a ton of down with shrouds. Some pine leaves as well. There were two dead ducklings, and a cracked egg with yolk.

Analysis: The minimum temperature is consistent over the two to three months as seen in graph 2. The temperature gradually increasing, from the lowest temperature of about 0.0 °C and the highest temperature around 6.0 °C. The maximum temperature, however, fluctuates. This most likely means that the temperature during the day is constantly increasing and decreasing. Because the nest was an overall success, there is a possibility in which the day time temperature does not affect the success rate of the nesting boxes.



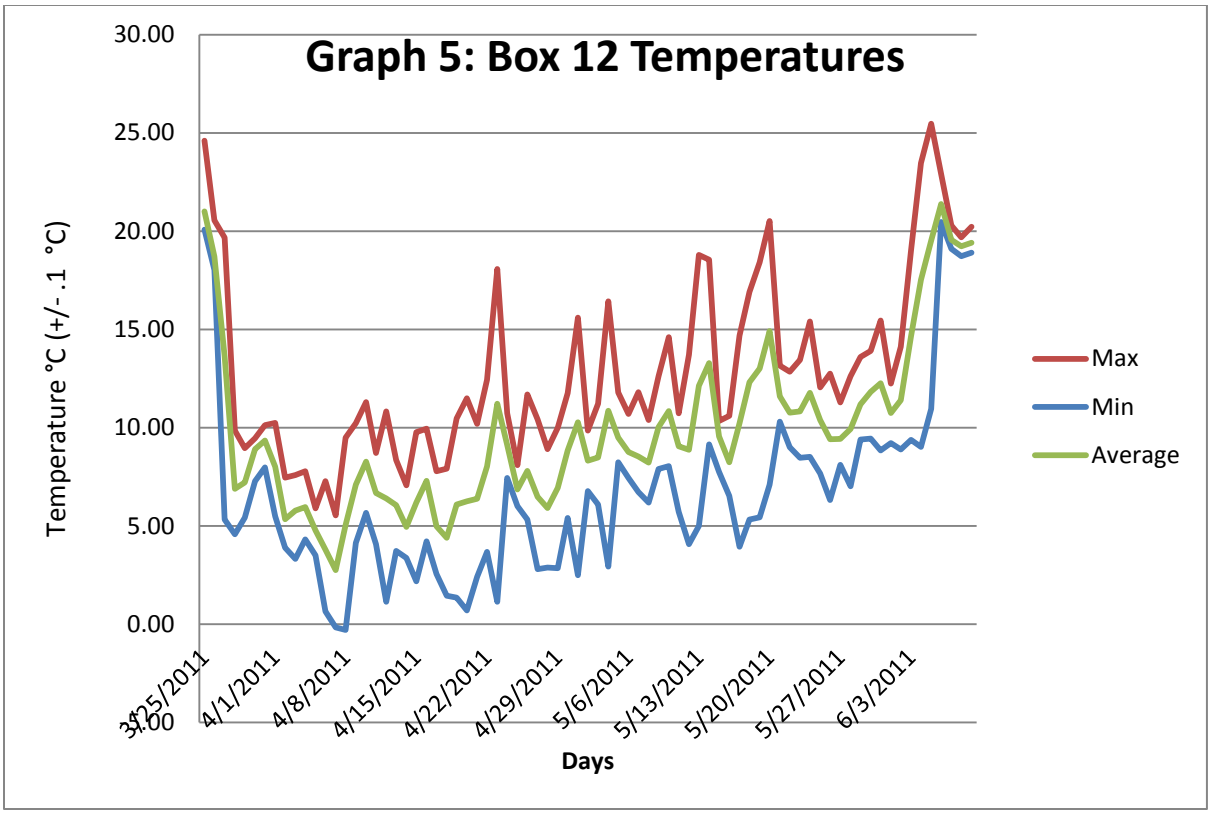
Box 4: There were a total of 17 eggs which did not hatch. The eggs were not white; they were speckled instead, with unusual colors, a color of brown and yellow, and the eggs were semi-translucent. The semi-translucent effect to the eggs meant the eggs had died.

Analysis: As seen in graph 3, the average and the minimum temperature slowly increased, but did not fluctuate as much as the maximum temperature. The maximum temperature was near a temperature of 20.0°C throughout the experiment. This means that the temperature was warmer than average throughout the day, and because the nest was unsuccessful, there is a correlation between warmer temperature and the amount of unsuccessful hatchings.



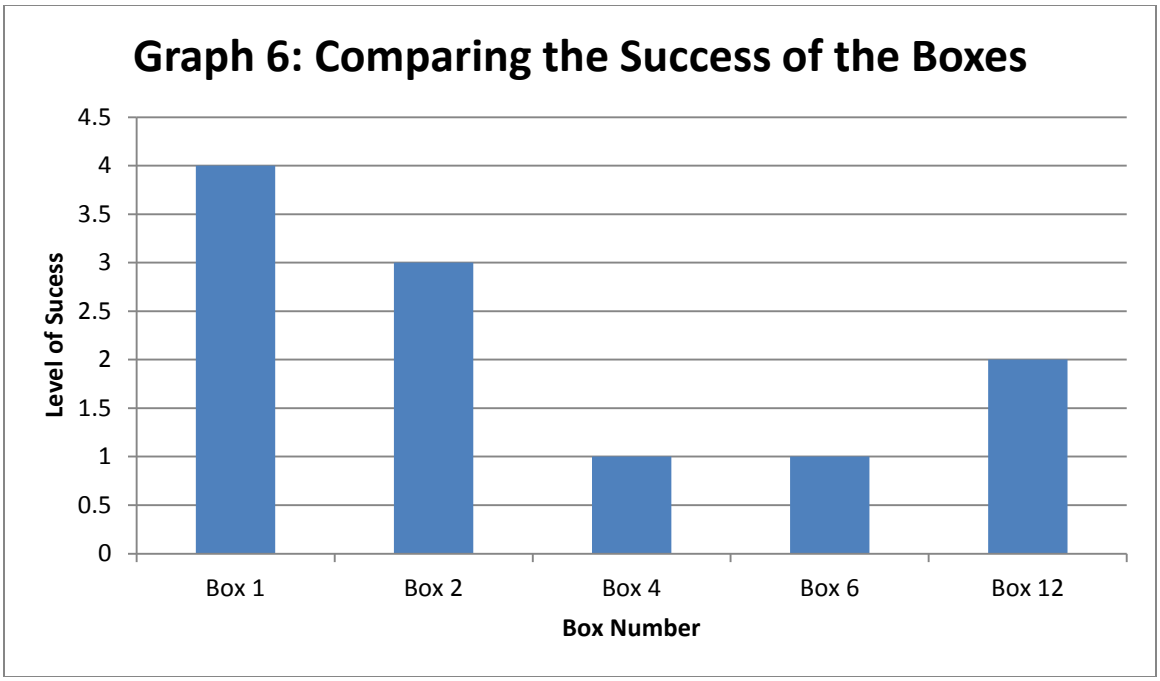
Box 6: There was a little down, and a bit of feathers on the first layer, and only one egg. There were three eggs on the second layer, and less down. The third layer barely had any shrouds, and there were ten eggs. In total, 14 eggs were found. All the eggs were white, and one was not hatched all the way; looked like it had been exposed to heat.

Analysis: As seen in graph 4, the maximum temperature and even the minimum temperature have increased. The minimum temperature, at its lowest, was 0.0°C, and it increased to around 8.0°C on 6/3/2011. The maximum temperature not only varied temperature from day to day, but peaked to the highest temperature of 27.0°C on 6/3/2011. The nest was not a success because when observed, the eggs had looked like they might have been exposed to heat, while the temperature probe recorded a dramatic increase of temperature.



Box 12: There were lots of moss and camouflage material that had covered the outside of the box. There were a total of five eggs, but two of the eggs were from different species of birds. The rest of the material was compacted underneath the moss layer.

Analysis: As seen in graph 4, even though the temperature fluctuated from day to day, both the minimum, and maximum temperatures stayed between a range of -1.0°C to 11.0°C, in the beginning of the experiment, 4.5°C to 15.5°C, in the middle of the experiment, and 9.5°C to 25.0°C, in the end of the experiment. Generally, the temperature increased over the two to three months. This box had other organisms occupying the box, thus a female wood duck probably did not want to lay her eggs there, and this most likely the reason why this nest was not a success.



This graph compares the boxes and their success rate of their nest. The level of success is based on a 0-5 range, 0-2 being unsuccessful nesting boxes, and 3-5 being successful. The observations were used to decide which boxes deserved what rank, and as it clearly shows that three of the nesting boxes were not successful.

Other Nesting Box Observations (boxes which did not have temperature probes):

Nest 3: There were a total of ten eggs found in the nest. Six came from a wood duck, and three of those were cracked. The other four eggs could have possibly come from a merganser. There were no down, which meant all the eggs did not hatch.

Nest 10: There was some down, and a total of three eggs, one of which was cracked. There were roughly about three shrouds, successful hatches. A temperature probe was found in this box; however the temperature probe did not retrieve information.

Box 11: Lots of down and the down is very dark. There are about 18 eggs that hatched. There was only one egg which did not hatch, and less down towards the third layer of the nest. There were two feathers, leaves, more chrysalis, little bugs, and more down. It is assumed that there might have been two hatchings in this nest.

Next to box 12: Only dead eggs were found. There were a lot of down, and eight shrouds. The dead eggs were brown and semi-translucent as well. There was one dead duck found in the box.

Conclusion:

The increase of global temperature has become a huge concern to effect it has on the population of wood ducks, and the number of eggs they hatch. This experiment tested if a warmer temperature has an effect on the success rate of wood duck eggs hatched.

By comparing the observed data for the five boxes which had temperature probes to the recorded temperatures from March 25, 2011, to June 5, 2011, there is a direct correlation (graph 6) with an increase of temperature, and the success rate of eggs hatched in each nest. There clearly was a difference of temperature range among each of the boxes. Some boxes, like box 1 and box 2, had a gradual increase of temperature, while box 4, 6, and 12 had a gradual increase of temperature for the average and minimum, but the maximum temperature remained high throughout the experiment. This increase of temperature for box 4, 5, and 6 might have caused the unsuccessful hatching which was observed in the lab. Generally, box 1 and 2, which had a lower maximum temperature turned out to have a better success rate.

Originally, it was thought that a warmer temperature would cause the hen to be able to warm and incubate her eggs better, but this is disproven because a warmer temperature might cause the eggs to not hatch. During the incubation process, the hen will sometimes take breaks, and this leaves the eggs exposed to outside factors, such as animals or heat (Coluccy, 2012). If the overall temperature is increasing, or the temperature around a box is significantly warmer, than a female wood duck might not have any reason to keep her eggs warm, and she might leave her nest more often, resulting in the eggs becoming over heated.

Although, it is difficult to say that the global warming could be one of the causes to the nests that did not hatch, there is a correlation. The full experiment could not have been preformed because in order to see if global warming is cause, the experiment needs to be repeated every spring for a couple of years to see if there is an increase of temperature, and increased of unsuccessful nests. There are other causes to fewer hatches that need to be considered such as nest dumping, other animals eating the eggs, and location.

One of the factors, temperature, does impact the success rate of a wood duck's eggs based on this experiment. The wood duck population in Washington should be closely observed in the future because fewer eggs hatched could severally impact the wood duck population.

Works Cited Page:

Burris, Ted (2010). Personal Communication.

Coluccy, John. "The Incubation Period For Female Waterfowl, Hatching a Nest Requires a Big Investment of Time and Energy." (2012). Print.

Davis, Brian. "NORTH AMERICAN WOOD DUCKS: STATUS AND CONSERVATION." Ducks Unlimited, 2012. Web.

Erickson, Glen E. *Habitat Preferences and Trapping Techniques for Wood Ducks in Northern Idaho*. Idaho: Idaho Cooperative Wildlife Research Unit, 1974. Print.

Hance, Jeremy. *Seals, Birds, and Alpine Plants Suffer under Climate Change* (2012). Print.

Hester, Eugene, and Jack Ermid. *The World of the Wood Duck*. Philadelphia and New York: J.B. Lippincott, 1973. Print.

Johnsgard, Paul A. *Waterfowl: Their Biology and Natural History*. University of Nebraska. Print.

Kirby, Ronald E., Lewis M. Cowardin, and John R. Tester. *Premigrational Movements and Behavior of Young Mallards and Wood Ducks in North-Central Minnesota*. Washington D.C.: Fish and Wild Life Service, 1989. Print.

Kortright, Francis H. *The Ducks, Geese and Swans of North America*. Toronto: American Wildlife Institute, 1943. Print.

Painting, Rob. *NASA: More Rapid Global Warming in Near Future* (2012). Print.

Appendix:
The initial raw data which was converted into the graphs (page 7)

The Recorded Temperature for Box 2			
	Temperature (°C)		
Date	Min	Max	Average
3/25/2011	20.27	22.09	21.07
3/26/2011	18.27	20.85	18.98
3/27/2011	5.15	20.84	13.86
3/28/2011	4.45	9.93	6.63
3/29/2011	5.46	8.59	7.04
3/30/2011	7.40	9.46	9.04
3/31/2011	8.18	10.17	9.40
4/1/2011	4.60	8.84	7.26
4/2/2011	3.09	8.03	4.62
4/3/2011	2.05	7.59	4.74
4/4/2011	3.80	6.88	5.28
4/5/2011	3.84	5.64	4.78
4/6/2011	0.79	8.99	3.90
4/7/2011	0.18	7.39	2.86
4/8/2011	-0.10	16.79	5.57
4/9/2011	4.24	10.33	7.05
4/10/2011	5.89	11.12	8.43
4/11/2011	4.18	10.07	6.84
4/12/2011	1.44	15.74	6.35
4/13/2011	3.75	7.73	5.98
4/14/2011	3.50	7.16	4.92
4/15/2011	2.13	10.41	6.30
4/16/2011	4.06	9.29	7.21
4/17/2011	2.28	11.55	5.15
4/18/2011	1.49	14.77	4.82
4/19/2011	1.18	15.88	6.51
4/20/2011	0.77	12.97	5.73
4/21/2011	2.74	10.01	5.80
4/22/2011	3.03	21.03	8.65
4/23/2011	0.97	23.15	10.55
4/24/2011	7.27	11.79	9.19
4/25/2011	5.83	9.01	7.00
4/26/2011	5.68	15.06	8.22

Box 2 Temperatures Continued

4/27/2011	3.01	9.69	6.21
4/28/2011	3.27	11.19	6.23
4/29/2011	3.00	13.56	7.17
4/30/2011	5.37	15.59	8.71
5/1/2011	2.61	20.79	9.90
5/2/2011	7.19	10.38	8.65
5/3/2011	6.34	15.51	8.96
5/4/2011	2.73	20.43	10.07
5/5/2011	8.41	13.72	9.82
5/6/2011	7.41	10.65	8.66
5/7/2011	6.93	11.84	8.51
5/8/2011	6.39	11.34	8.24
5/9/2011	7.58	12.17	9.62
5/10/2011	8.11	18.03	11.12
5/11/2011	5.88	10.69	9.13
5/12/2011	3.76	15.53	8.63
5/13/2011	4.73	18.97	11.51
5/14/2011	8.96	18.18	12.71
5/15/2011	8.12	10.82	9.74
5/16/2011	6.93	10.71	8.45
5/17/2011	3.78	18.85	9.80
5/18/2011	5.40	21.76	11.88
5/19/2011	5.62	22.81	12.70
5/20/2011	7.15	21.54	13.85
5/21/2011	10.31	12.24	11.33
5/22/2011	9.30	13.25	10.99
5/23/2011	8.51	15.22	10.92
5/24/2011	8.60	19.45	12.27
5/25/2011	7.89	11.78	10.41
5/26/2011	6.79	13.48	9.49
5/27/2011	8.13	13.39	9.72
5/28/2011	7.14	12.48	9.49
5/29/2011	8.84	13.07	10.75
5/30/2011	9.48	15.04	11.66
5/31/2011	8.96	16.79	12.18
6/1/2011	9.81	12.68	11.02
6/2/2011	9.12	13.66	11.18
6/3/2011	9.38	20.02	13.80
6/4/2011	9.41	24.52	16.28
6/5/2011	11.34	25.04	18.28

Recorded Temperature for Box 4			
	Temperature (°C)		
Date	Min	Max	Average
3/25/2011	20.20	21.25	20.79
3/26/2011	18.03	20.62	18.74
3/27/2011	4.99	19.90	13.74
3/28/2011	4.25	10.07	6.71
3/29/2011	5.27	8.81	7.04
3/30/2011	7.46	9.44	9.01
3/31/2011	7.46	10.70	9.41
4/1/2011	4.46	9.29	7.26
4/2/2011	2.85	9.23	4.68
4/3/2011	1.44	8.66	5.06
4/4/2011	3.75	7.24	5.36
4/5/2011	3.58	6.02	4.82
4/6/2011	0.25	10.99	4.29
4/7/2011	-0.37	8.28	3.13
4/8/2011	-0.86	16.71	6.29
4/9/2011	3.97	12.36	7.58
4/10/2011	5.64	12.16	8.53
4/11/2011	3.60	11.50	7.15
4/12/2011	0.43	15.11	6.79
4/13/2011	3.30	8.52	5.83
4/14/2011	3.17	7.91	4.81
4/15/2011	1.57	12.82	6.99
4/16/2011	3.91	10.67	7.59
4/17/2011	1.90	12.71	5.77
4/18/2011	1.13	14.01	5.21
4/19/2011	0.58	15.51	7.06
4/20/2011	-0.45	13.16	5.96
4/21/2011	2.24	12.16	6.29
4/22/2011	2.38	20.32	9.37
4/23/2011	0.09	23.35	11.23
4/24/2011	6.94	12.45	9.12
4/25/2011	5.77	9.36	6.91
4/26/2011	5.51	15.08	8.44
4/27/2011	2.58	10.72	6.18
4/28/2011	3.07	11.39	6.55
4/29/2011	2.21	12.81	7.39

Box 4 Temperatures Continued

4/30/2011	4.84	14.74	9.01
5/1/2011	1.34	22.07	10.47
5/2/2011	7.06	9.96	8.35
5/3/2011	6.00	16.88	9.40
5/4/2011	2.04	21.46	10.81
5/5/2011	7.96	14.70	9.69
5/6/2011	7.13	11.08	8.64
5/7/2011	6.65	12.57	8.64
5/8/2011	6.07	13.40	8.75
5/9/2011	7.65	13.36	10.21
5/10/2011	8.05	19.37	11.88
5/11/2011	5.52	10.86	9.04
5/12/2011	3.11	18.09	9.29
5/13/2011	3.90	21.20	12.20
5/14/2011	8.43	19.99	13.28
5/15/2011	7.98	10.53	9.73
5/16/2011	6.91	12.04	8.81
5/17/2011	3.13	21.52	10.88
5/18/2011	4.72	23.96	12.66
5/19/2011	4.63	24.24	13.30
5/20/2011	6.19	23.51	14.24
5/21/2011	9.94	12.84	11.34
5/22/2011	9.05	14.78	11.36
5/23/2011	8.39	17.03	11.52
5/24/2011	6.94	20.29	12.81
5/25/2011	7.69	12.20	10.34
5/26/2011	6.85	14.00	9.86
5/27/2011	7.89	13.92	9.89
5/28/2011	6.70	13.78	9.97
5/29/2011	8.95	13.74	11.06
5/30/2011	9.32	16.21	12.18
5/31/2011	8.53	17.92	12.55
6/1/2011	9.65	14.07	11.21
6/2/2011	8.96	15.86	11.76
6/3/2011	8.68	23.03	15.10
6/4/2011	8.50	29.25	17.83
6/5/2011	10.52	27.32	18.33

Recorded Temperature for Box 6			
	Temperature (°C)		
Date	Min	Max	Average
3/25/2011	20.09	22.80	20.85
3/26/2011	18.10	20.61	18.79
3/27/2011	5.14	19.79	13.72
3/28/2011	4.36	11.10	7.02
3/29/2011	5.26	8.70	6.98
3/30/2011	7.21	9.53	9.10
3/31/2011	8.36	10.37	9.57
4/1/2011	4.82	8.96	7.37
4/2/2011	2.81	9.57	4.71
4/3/2011	2.10	7.92	4.99
4/4/2011	3.90	6.92	5.35
4/5/2011	3.96	5.97	5.02
4/6/2011	0.61	9.37	4.38
4/7/2011	-0.01	6.68	3.39
4/8/2011	0.71	17.38	6.97
4/9/2011	4.24	11.15	7.70
4/10/2011	6.17	11.97	9.14
4/11/2011	5.25	11.25	7.47
4/12/2011	2.05	17.06	8.11
4/13/2011	4.43	8.58	6.65
4/14/2011	4.19	8.51	5.63
4/15/2011	3.36	13.64	8.02
4/16/2011	5.58	11.80	8.73
4/17/2011	3.39	15.72	7.12
4/18/2011	2.63	13.89	6.21
4/19/2011	2.29	13.76	7.55
4/20/2011	1.44	15.13	7.69
4/21/2011	3.23	12.65	7.05
4/22/2011	3.96	21.32	10.53
4/23/2011	1.36	23.37	12.04
4/24/2011	8.20	12.81	9.89
4/25/2011	6.25	9.19	7.78
4/26/2011	6.68	13.94	9.02
4/27/2011	3.21	11.19	7.07

Box 6 Temperatures Continued

4/28/2011	3.55	11.64	6.89
4/29/2011	4.22	12.77	8.54
4/30/2011	6.49	14.66	10.31
5/1/2011	3.37	20.87	11.13
5/2/2011	7.47	10.57	9.12
5/3/2011	7.18	17.91	10.17
5/4/2011	3.90	22.10	11.80
5/5/2011	8.58	14.47	10.52
5/6/2011	8.33	11.99	9.62
5/7/2011	7.99	12.38	9.48
5/8/2011	7.63	14.07	9.87
5/9/2011	9.02	14.62	11.42
5/10/2011	9.01	18.60	12.21
5/11/2011	6.69	11.80	9.98
5/12/2011	4.15	16.95	10.01
5/13/2011	5.60	24.20	13.68
5/14/2011	9.64	21.71	14.33
5/15/2011	8.77	11.57	10.42
5/16/2011	7.47	12.58	9.67
5/17/2011	5.26	21.16	11.98
5/18/2011	6.10	22.60	13.57
5/19/2011	6.69	22.46	13.75
5/20/2011	6.11	22.00	13.88
5/21/2011	9.68	12.26	11.04
5/22/2011	9.02	14.96	11.18
5/23/2011	8.38	15.77	11.26
5/24/2011	8.11	18.32	12.26
5/25/2011	7.85	11.85	10.22
5/26/2011	6.91	13.58	9.75
5/27/2011	7.86	12.31	9.54
5/28/2011	6.64	13.40	9.70
5/29/2011	8.89	13.60	10.99
5/30/2011	9.45	15.46	12.00
5/31/2011	8.62	16.51	12.17
6/1/2011	9.67	13.71	11.00
6/2/2011	8.95	15.24	11.72
6/3/2011	8.93	23.47	14.90
6/4/2011	8.37	27.56	17.11
6/5/2011	10.23	24.69	18.10

Recorded Temperature for Box 12			
	Temperature (°C)		
Date	Min	Max	Average
3/25/2011	20.07	24.60	21.01
3/26/2011	18.02	20.54	18.71
3/27/2011	5.32	19.67	13.63
3/28/2011	4.57	9.85	6.88
3/29/2011	5.42	8.95	7.21
3/30/2011	7.27	9.45	8.91
3/31/2011	7.97	10.12	9.34
4/1/2011	5.49	10.24	8.01
4/2/2011	3.89	7.45	5.33
4/3/2011	3.32	7.58	5.77
4/4/2011	4.31	7.78	5.96
4/5/2011	3.49	5.89	4.77
4/6/2011	0.64	7.27	3.78
4/7/2011	-0.16	5.53	2.75
4/8/2011	-0.30	9.49	5.05
4/9/2011	4.13	10.22	7.10
4/10/2011	5.66	11.29	8.28
4/11/2011	4.06	8.71	6.67
4/12/2011	1.13	10.83	6.39
4/13/2011	3.72	8.35	6.05
4/14/2011	3.37	7.07	4.95
4/15/2011	2.18	9.77	6.18
4/16/2011	4.21	9.94	7.29
4/17/2011	2.55	7.78	4.98
4/18/2011	1.45	7.91	4.39
4/19/2011	1.34	10.47	6.08
4/20/2011	0.70	11.50	6.25
4/21/2011	2.40	10.19	6.37
4/22/2011	3.67	12.44	8.02
4/23/2011	1.14	18.07	11.21
4/24/2011	7.43	10.73	9.11
4/25/2011	6.00	8.09	6.86
4/26/2011	5.32	11.68	7.80
4/27/2011	2.79	10.42	6.48
4/28/2011	2.88	8.90	5.91
4/29/2011	2.84	9.99	6.93

Box 12 Temperatures Continued

4/30/2011	5.41	11.76	8.83
5/1/2011	2.48	15.60	10.27
5/2/2011	6.77	9.85	8.32
5/3/2011	6.08	11.22	8.47
5/4/2011	2.92	16.42	10.85
5/5/2011	8.23	11.79	9.50
5/6/2011	7.43	10.70	8.76
5/7/2011	6.72	11.80	8.53
5/8/2011	6.18	10.38	8.23
5/9/2011	7.89	12.62	10.02
5/10/2011	8.04	14.61	10.84
5/11/2011	5.71	10.73	9.05
5/12/2011	4.06	13.71	8.88
5/13/2011	5.00	18.79	12.13
5/14/2011	9.14	18.55	13.28
5/15/2011	7.75	10.34	9.55
5/16/2011	6.53	10.59	8.24
5/17/2011	3.94	14.69	10.22
5/18/2011	5.32	16.90	12.30
5/19/2011	5.43	18.41	13.00
5/20/2011	7.10	20.51	14.92
5/21/2011	10.30	13.16	11.58
5/22/2011	9.00	12.84	10.76
5/23/2011	8.47	13.44	10.82
5/24/2011	8.52	15.40	11.78
5/25/2011	7.66	12.05	10.38
5/26/2011	6.31	12.75	9.41
5/27/2011	8.10	11.28	9.43
5/28/2011	7.01	12.61	9.93
5/29/2011	9.39	13.59	11.18
5/30/2011	9.44	13.91	11.82
5/31/2011	8.84	15.45	12.26
6/1/2011	9.22	12.24	10.75
6/2/2011	8.88	14.12	11.40
6/3/2011	9.38	19.01	14.65
6/4/2011	9.02	23.46	17.53
6/5/2011	10.96	25.47	19.52
6/6/2011	20.46	22.91	21.37
6/7/2011	19.10	20.29	19.55
6/8/2011	18.72	19.69	19.23

Recorded Temperature for Box 1			
	Temperature (°C)		
Date	Min	Max	Average
3/25/2011	20.14	21.67	20.79
3/26/2011	18.13	20.65	18.82
3/27/2011	5.02	19.85	13.70
3/28/2011	4.31	10.14	6.77
3/29/2011	5.26	8.69	6.97
3/30/2011	7.62	9.44	9.05
3/31/2011	8.09	10.03	9.35
4/1/2011	4.32	9.35	7.26
4/2/2011	2.79	7.95	4.52
4/3/2011	1.67	7.78	4.79
4/4/2011	3.77	7.17	5.33
4/5/2011	3.57	5.79	4.79
4/6/2011	0.56	9.07	3.96
4/7/2011	-0.24	6.99	2.96
4/8/2011	-0.54	14.67	5.88
4/9/2011	4.21	11.41	7.48
4/10/2011	5.82	11.73	8.59
4/11/2011	4.00	10.47	6.91
4/12/2011	0.78	13.57	6.64
4/13/2011	3.40	8.03	5.84
4/14/2011	3.29	8.06	4.86
4/15/2011	1.70	12.73	7.05
4/16/2011	4.16	9.32	7.19
4/17/2011	2.29	9.97	5.23
4/18/2011	1.61	11.22	4.78
4/19/2011	0.91	12.33	6.07
4/20/2011	0.41	11.93	5.51
4/21/2011	2.74	10.64	5.98
4/22/2011	3.00	16.16	8.27
4/23/2011	0.77	20.28	10.17
4/24/2011	7.50	11.75	9.21
4/25/2011	5.82	8.36	6.97
4/26/2011	5.74	12.25	8.09
4/27/2011	2.82	9.83	6.22

Box 1 Temperatures Continued

4/28/2011	3.19	9.73	5.80
4/29/2011	2.65	11.79	7.00
4/30/2011	5.11	12.87	8.37
5/1/2011	1.73	18.78	9.24
5/2/2011	7.24	10.14	8.51
5/3/2011	7.24	13.93	8.94
5/4/2011	2.58	18.50	9.86
5/5/2011	8.02	13.88	9.76
5/6/2011	7.48	10.83	8.75
5/7/2011	7.03	11.03	8.50
5/8/2011	6.49	11.92	8.62
5/9/2011	7.95	12.95	10.14
5/10/2011	-8.20	16.48	11.20
5/11/2011	6.08	12.21	9.30
5/12/2011	3.78	13.99	8.47
5/13/2011	4.48	18.76	11.35
5/14/2011	8.74	18.37	12.99
5/15/2011	7.97	13.41	9.85
5/16/2011	6.98	10.87	8.54
5/17/2011	3.60	17.43	9.71
5/18/2011	4.97	19.45	11.43
5/19/2011	5.04	20.92	12.17
5/20/2011	6.83	21.03	13.50
5/21/2011	10.14	12.61	11.40
5/22/2011	9.50	13.94	11.35
5/23/2011	0.77	15.92	11.30
5/24/2011	8.52	17.79	12.59
5/25/2011	8.37	28.63	12.44
5/26/2011	7.12	21.59	13.02
5/27/2011	8.55	16.85	11.59
5/28/2011	7.22	17.44	12.88
5/29/2011	10.57	18.21	13.69
5/30/2011	12.62	24.95	15.62
5/31/2011	13.87	17.43	15.33
6/1/2011	9.95	15.79	12.70
6/2/2011	11.84	20.50	14.78
6/3/2011	13.76	21.62	16.92
6/4/2011	10.90	26.28	18.05
6/5/2011	13.10	23.52	18.40