

# 11 Tests for the Effects of Two Factors (Cont'd)

MTH 3240 Environmental Statistics

Spring 2020

# Main Effects Masked by an Interaction

- Recall that when checking for significance in a two-factor ANOVA, we **first** look at the results of the test for the **interaction effect**.

# Main Effects Masked by an Interaction

- Recall that when checking for significance in a two-factor ANOVA, we **first** look at the results of the test for the **interaction effect**.

We only proceed to the tests for **main effects** if the **interaction** is **not significant**.

## Example

On June 8, 2000 the oil tanker T/V Posavina spilled 59,000 gallons of oil into the Chelsea River, Massachusetts, oiling the shoreline.

## Example

On June 8, 2000 the oil tanker T/V Posavina spilled 59,000 gallons of oil into the Chelsea River, Massachusetts, oiling the shoreline.

The reclamation included restoration of a degraded salt marsh along **Mill Creek**, located on the Chelsea River. The restoration involved removal of roots of the invasive reed *Phragmites*.

A **before-after-control-impact** study was carried out to examine the effectiveness of the restoration project in decreasing Phragmites cover.

**Heights** of Phragmites' were measured in the **Mill Creek** marsh and an adjacent, unrestored **control** marsh on September 1, 2005, just **before** the restoration of the Mill Creek marsh, and again in 2007, two years **after** the restoration.

The table below shows, for three 1 m<sup>2</sup> quadrats selected from each marsh before the restoration and three selected from each marsh after the restoration, the mean **height** (cm) of Phragmites plants in the quadrat.

		Period		
		Before	After	
Site	Control	64	179	$\bar{Y}_{1.} = 201.8$
		80	300	
		282	306	
	Mill Creek	254	210	$\bar{Y}_{2.} = 225.5$
		300	154	
		284	154	
		$\bar{Y}_{.1} = 210.7$	$\bar{Y}_{.2} = 216.7$	

The **ANOVA table** is below.

Source	DF	SS	MS	F	P-value
Period	1	108	108	0.020	0.8909
Site	1	1680	1680	0.312	0.5918
Interaction	1	38760	38760	7.195	0.0278
Error	8	43096	5387		
Total	11	83644			



The **ANOVA table** is below.

Source	DF	SS	MS	F	P-value
Period	1	108	108	0.020	0.8909
Site	1	1680	1680	0.312	0.5918
Interaction	1	38760	38760	7.195	0.0278
Error	8	43096	5387		
Total	11	83644			

The **interaction** effect is statistically **significant**, so there's **no need** to proceed to the tests for main effects – we know, based on the significant interaction, that *both* **Period** and **Site** have effects.

- The reason for proceeding in this manner (looking at the interaction first) is that main effects can be "**masked**" by an interaction effect.

- The reason for proceeding in this manner (looking at the interaction first) is that main effects can be **"masked"** by an interaction effect.

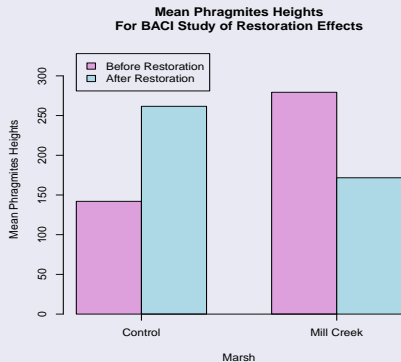
The following example illustrates.

## Example (Cont'd)

Here again are the data from the **before-after-control-impact** study of the restoration project for decreasing Phragmites plants heights near the oil-degraded **Mill Creek** salt marsh and a nearby **control** site.

		Period		
		Before	After	
Site	Control	64	179	$\bar{Y}_{1.} = 201.8$
		80	300	
		282	306	
	Mill Creek	254	210	$\bar{Y}_{2.} = 225.5$
		300	154	
		284	154	
		$\bar{Y}_{.1} = 210.7$	$\bar{Y}_{.2} = 216.7$	

The goal is to decide if the heights of Phragmites decreased more at the restored Mill Creek site than at the unrestored control site. A bar plot of the group means is below.



The **ANOVA table** is shown again below.

Source	DF	SS	MS	F	P-value
Period	1	108	108	0.020	0.8909
Site	1	1680	1680	0.312	0.5918
Interaction	1	38760	38760	7.195	0.0278
Error	8	43096	5387		
Total	11	83644			

The **interaction** effect is statistically **significant**, which, coupled with the graph on the previous slide, indicates that Phragmites **heights decreased more at the Mill Creek site than at the control site.**

But **neither main effect is significant**, even though we **know**, because the **interaction is significant**, that:



But **neither main effect is significant**, even though we **know**, because the **interaction is significant**, that:

1. **Period** had an effect, i.e. the heights changed over the two periods – but the direction of the before-to-after change was different at two sites.

But **neither main effect is significant**, even though we **know**, because the **interaction is significant**, that:

1. **Period** had an effect, i.e. the heights changed over the two periods – but the direction of the before-to-after change was different at two sites.
2. **Site** had an effect, i.e. the heights differed across the two sites – but the sign of the between-sites difference changed from before to after.

But **neither main effect is significant**, even though we **know**, because the **interaction is significant**, that:

1. **Period** had an effect, i.e. the heights changed over the two periods – but the direction of the before-to-after change was different at two sites.
2. **Site** had an effect, i.e. the heights differed across the two sites – but the sign of the between-sites difference changed from before to after.

The **main effects** of **period** and **marsh** have been **”masked”** by the **interaction effect**.

But **neither main effect is significant**, even though we **know**, because the **interaction is significant**, that:

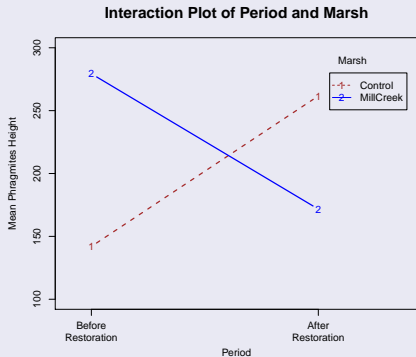
1. **Period** had an effect, i.e. the heights changed over the two periods – but the direction of the before-to-after change was different at two sites.
2. **Site** had an effect, i.e. the heights differed across the two sites – but the sign of the between-sites difference changed from before to after.

The **main effects** of **period** and **marsh** have been "**masked**" by the **interaction effect**.

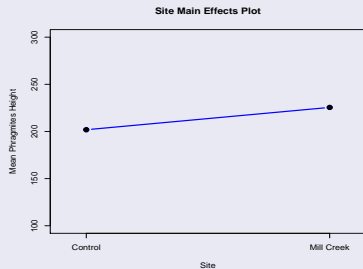
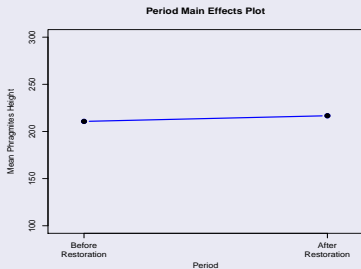
This is illustrated by the **group**, **row**, and **column means** in the next table and the **interaction plot** and **main effects plots** that follow it.

		Period		
		Before	After	
Site	Control	$\bar{y}_{11} =$ <b>142.0</b>	$\bar{y}_{12} =$ <b>261.7</b>	$\bar{y}_{1\cdot} =$ 201.8
	Mill Creek	$\bar{y}_{21} =$ <b>279.3</b>	$\bar{y}_{22} =$ <b>171.7</b>	$\bar{y}_{2\cdot} =$ 225.5
		$\bar{y}_{\cdot 1} =$ 210.7	$\bar{y}_{\cdot 2} =$ 216.7	

## Statistically significant interaction effect:



## Main effects **not statistically significant**:



# Patterns in Interaction Plots

- To wrap up the discussion of **two-factor ANOVA**, Some **interaction plots** showing various combinations of effects are on the slides ahead.

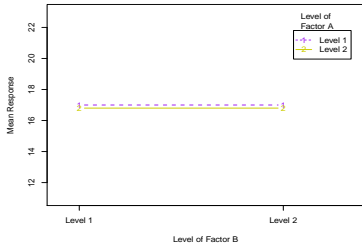


# Patterns in Interaction Plots

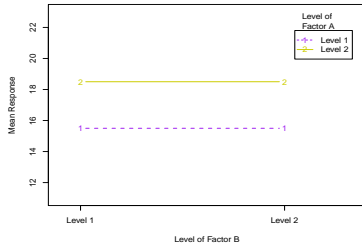
- To wrap up the discussion of **two-factor ANOVA**, Some **interaction plots** showing various combinations of effects are on the slides ahead.

For each plot, there are **two** levels of **Factor A** and **two** levels of **Factor B**.

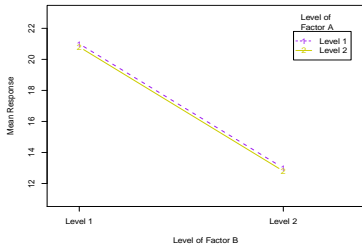
**No A Effect, No B Effect, No AB Interaction Effect**  
Interaction Plot of Factors A and B



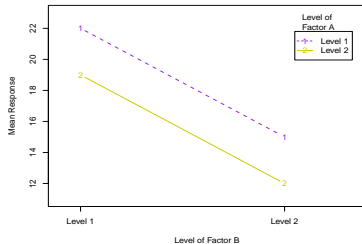
**A Effect, No B Effect, No AB Interaction Effect**  
Interaction Plot of Factors A and B



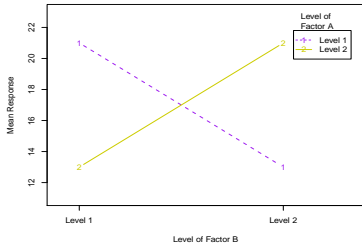
**B Effect, No A Effect, No AB Interaction Effect**  
Interaction Plot of Factors A and B



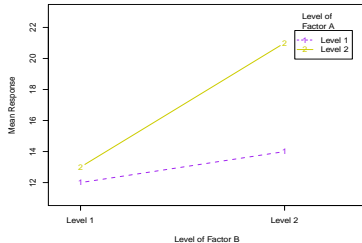
**A Effect, B Effect, No AB Interaction Effect**  
Interaction Plot of Factors A and B



**AB Interaction Effect**  
Interaction Plot of Factors A and B



**AB Interaction Effect**  
Interaction Plot of Factors A and B



**AB Interaction Effect**  
Interaction Plot of Factors A and B

