Cowboy Science

What You See is

Not What You Get

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What is Cowboy Science?

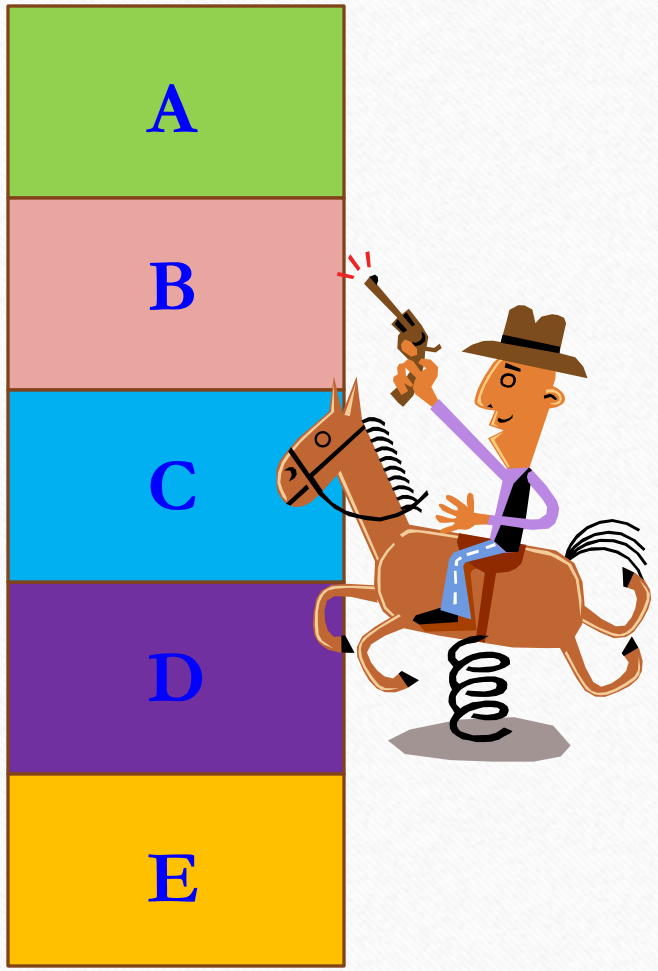
- "Quick and Dirty" trials
- "Demo Plots"
- This approach can yield results that are statistically invalid and/or biologically untrue
- Using flawed data for management decisions can really get you in the end

Be wary of seeing what you want to see…

- Foresters gather around the best-looking plot or the biggest tree like it's a campfire
- Don't fall for your own hopeful outcomes!
- Instead, rely on unbiased data generated from well-designed studies

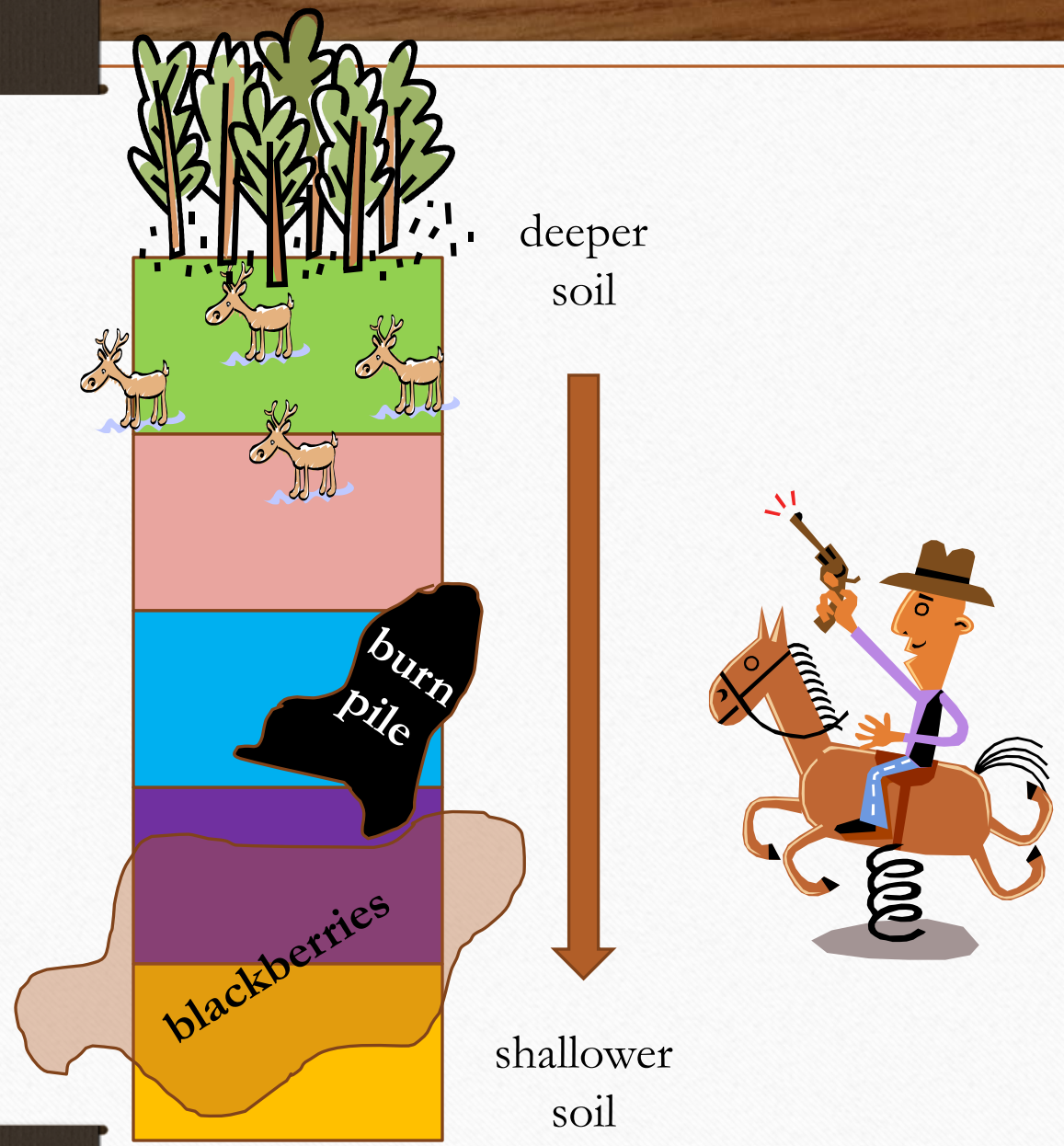
An Example

- Cowboy Joe set up a trial to compare efficacy and phytotoxicity of 5 new herbicide treatments
- His pal, Cowgirl Cathy, likes to use herbicide C, but Joe's boss made him do a trial anyway
- He established one large plot per treatment, each with 150 seedlings
- He concluded that herbicide C was best and decided to use that treatment from now on
- So….what's the problem?



The Problem

- Cowboy Joe's site conditions are not uniform such that some plots have more favorable conditions than others - the treatments are confounded
- Cowboy Joe may be biased by his friend's opinion
- He only tested the 5 new treatments and did not include a control



Confounding

- Definition: to mingle so that the elements cannot be distinguished or separated
- Can result in differences among treatments which are not actually due to the treatment

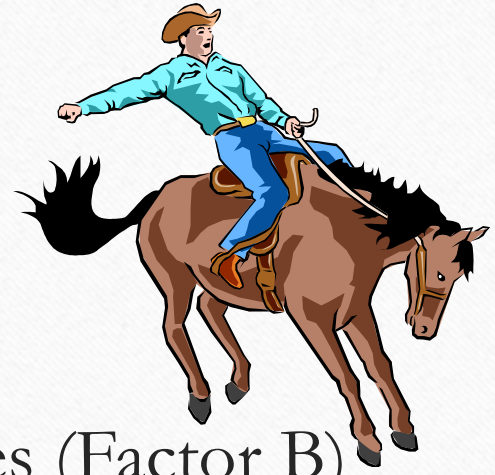
Bias

- Definition: a tendency or inclination that influences or prevents unprejudiced consideration of a question
- Can produce results that over- or under-estimate differences among treatments

Treatments

- The treatment is the one factor that is intentionally changed for the study
- All other factors must stay the same to be able to isolate responses to the treatment in question
- Always include a control treatment (the usual method) for comparison

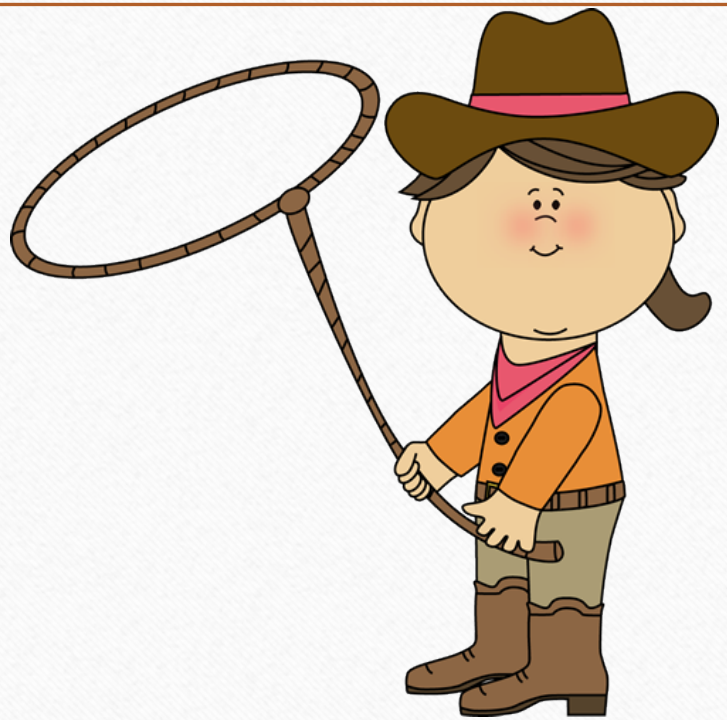
Factorial Treatments



- Allows you to evaluate two treatments in the same study
  - For example, herbicide type (Factor A) and tree species (Factor B)
  - You must include all combinations for a true factorial
- Allows you determine if there are interactions between the two factors
  - For example, do all species respond the same to the products?
- Keep it simple; do not go beyond two factors!

The Three R's of Study Design

- ✓ Randomization
- ✓ Replication
- ✓ Representation

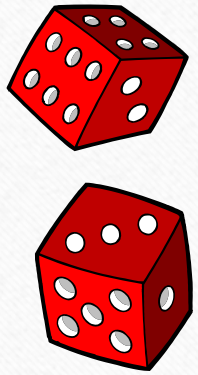


Randomization

- The circumstance in which each plot/tree could have been assigned to any of the treatments
- Prevents bias

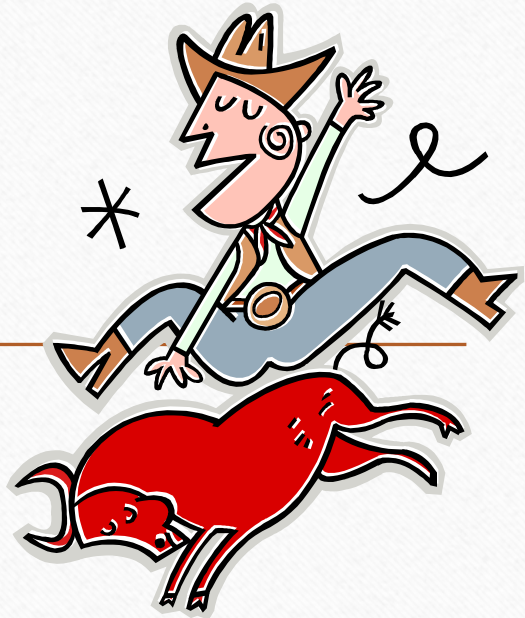
Implementing Randomization

- Assign treatments to trees or plots using a random, non-biased method
  - roll the dice
  - draw a playing card
  - use a random-number generator
  - draw out of a hat



Replication

- Gives the ability to determine if variation is due to treatments or not
- Failure to replicate makes it impossible to make valid comparisons between treatments
- Without replication, all you have is a one-time event which may or may not be repeatable



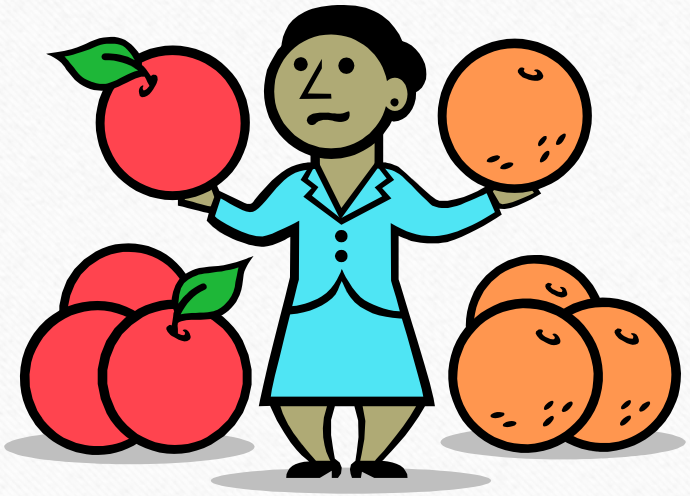
If this cowboy rides the bull successfully just once, can we really predict that he will do so from now on?

Implementing Replication

- Replicate by individual trees or plots
  - Plots are usually best for forestry trials
  - Individual trees are good for short-term studies in small areas with uniform conditions
- Number of replications
  - Recommend a minimum of four replications
  - More is better than less!!

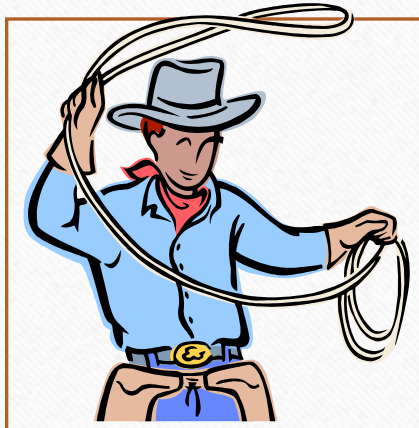
Representation

- Gives the ability to apply the results to the specific trees/situations of interest
- Provides the "Scope of Inference" for the data, i.e. defines the population and circumstances to which the results can be applied



Implementing Representation

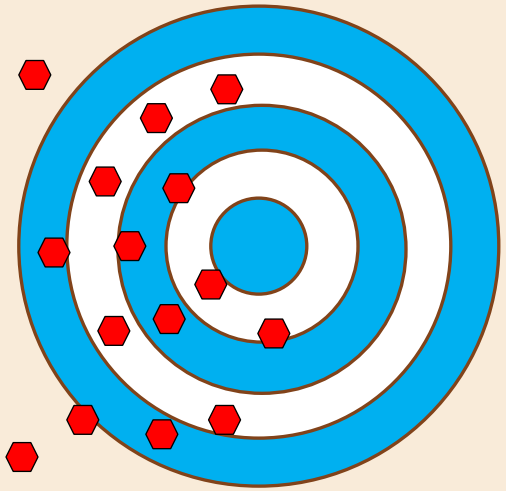
- Think through the desired outcome of the study
- What is the desired scope?
  - What population? Which circumstances?
  - Consider: what, when, where, why, who, how
- With this in mind, choose your study population and circumstances accordingly



What about "operational" trials?

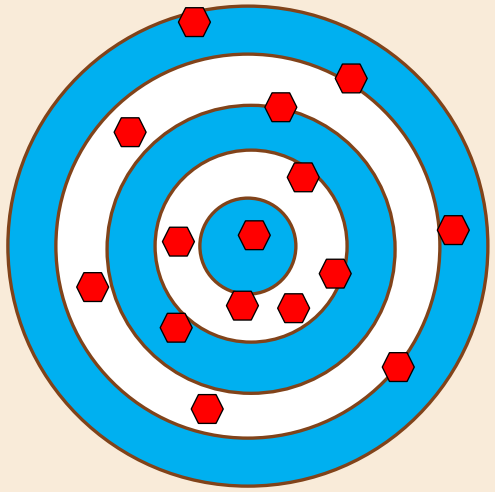
- The study objective is to generate results which can be applied to operational practices
- However, using operational practices during the study often results in excess "noise" (variation) and an inability to assess treatment effects with accuracy and precision
- Therefore, set up studies with extra care to minimize "noise" and isolate the variation due to treatment(s) in question

A quality study design maximizes Accuracy and Precision



low accuracy
and
low precision

(biased and
imprecise)



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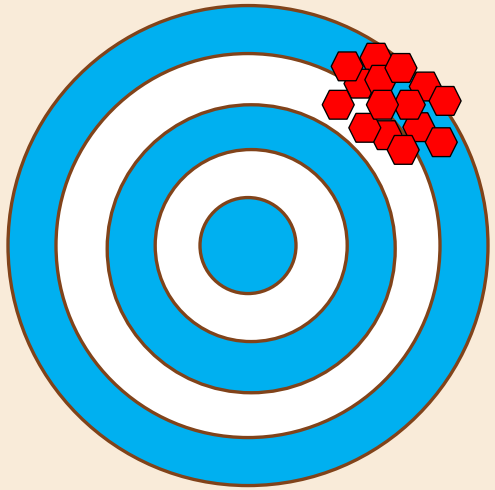

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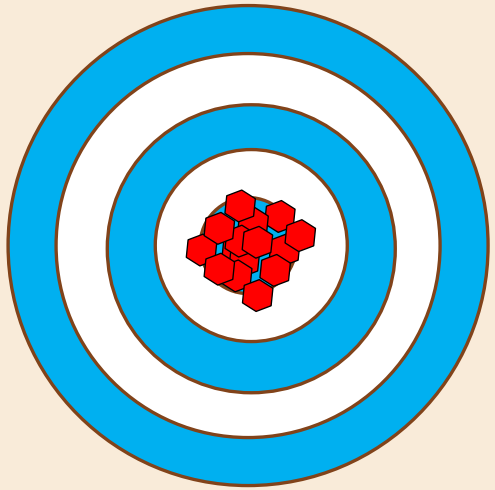

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Completely Randomized Design

- Plots of trees (or individual trees) are each randomly assigned to a treatment
- Must be installed in an area that is relatively uniform

Individual trees as replicates

3 treatments

30 trees per treatment

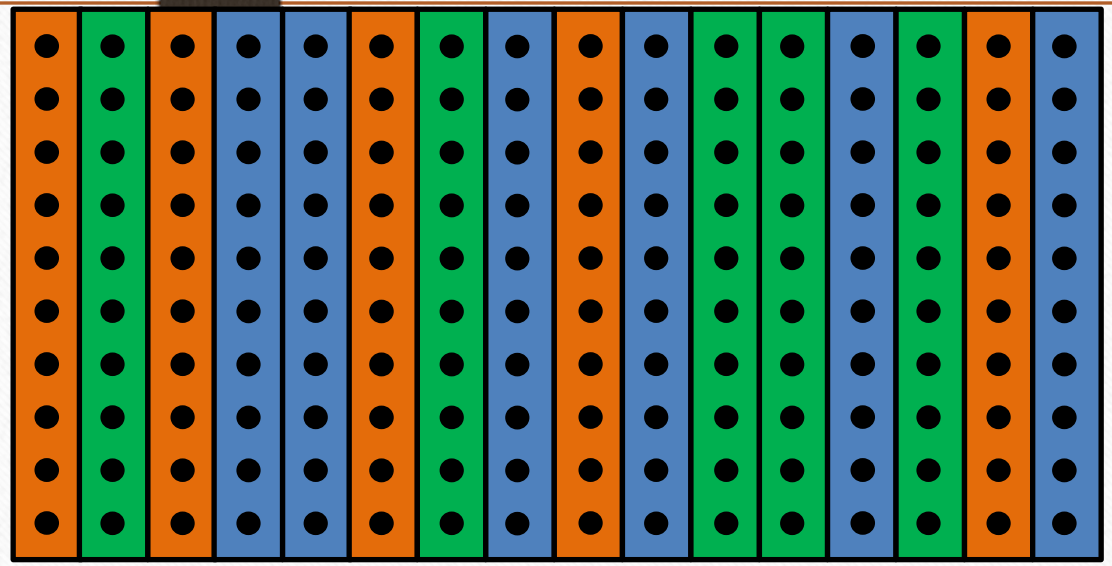
05	04	21	19	03	27	09	27	10	12
10	14	15	16	16	18	02	19	30	25
01	28	12	05	03	06	20	07	06	08
07	18	09	10	01	11	17	11	13	18
29	19	04	20	20	23	29	24	30	28
26	22	30	01	28	03	04	22	05	27
06	26	09	11	23	08	07	15	25	08
02	17	12	13	21	21	22	14	24	23
29	24	14	25	15	26	16	02	17	13

Row plots as replicates

3 treatments

5 replications (rows)

10 trees per row

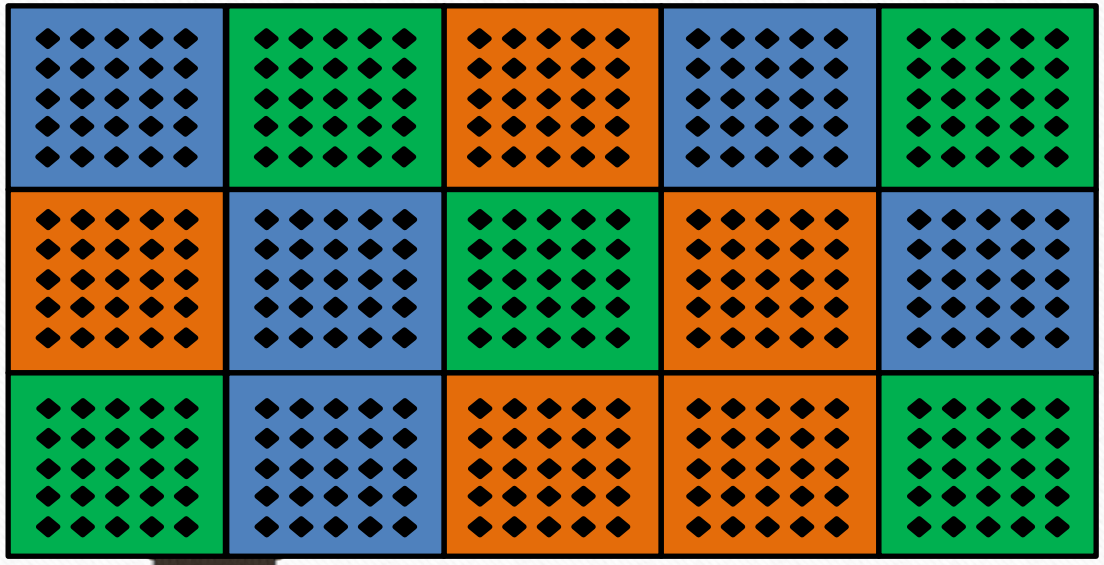


Square plots as replicates

3 treatments

5 replications (plots)

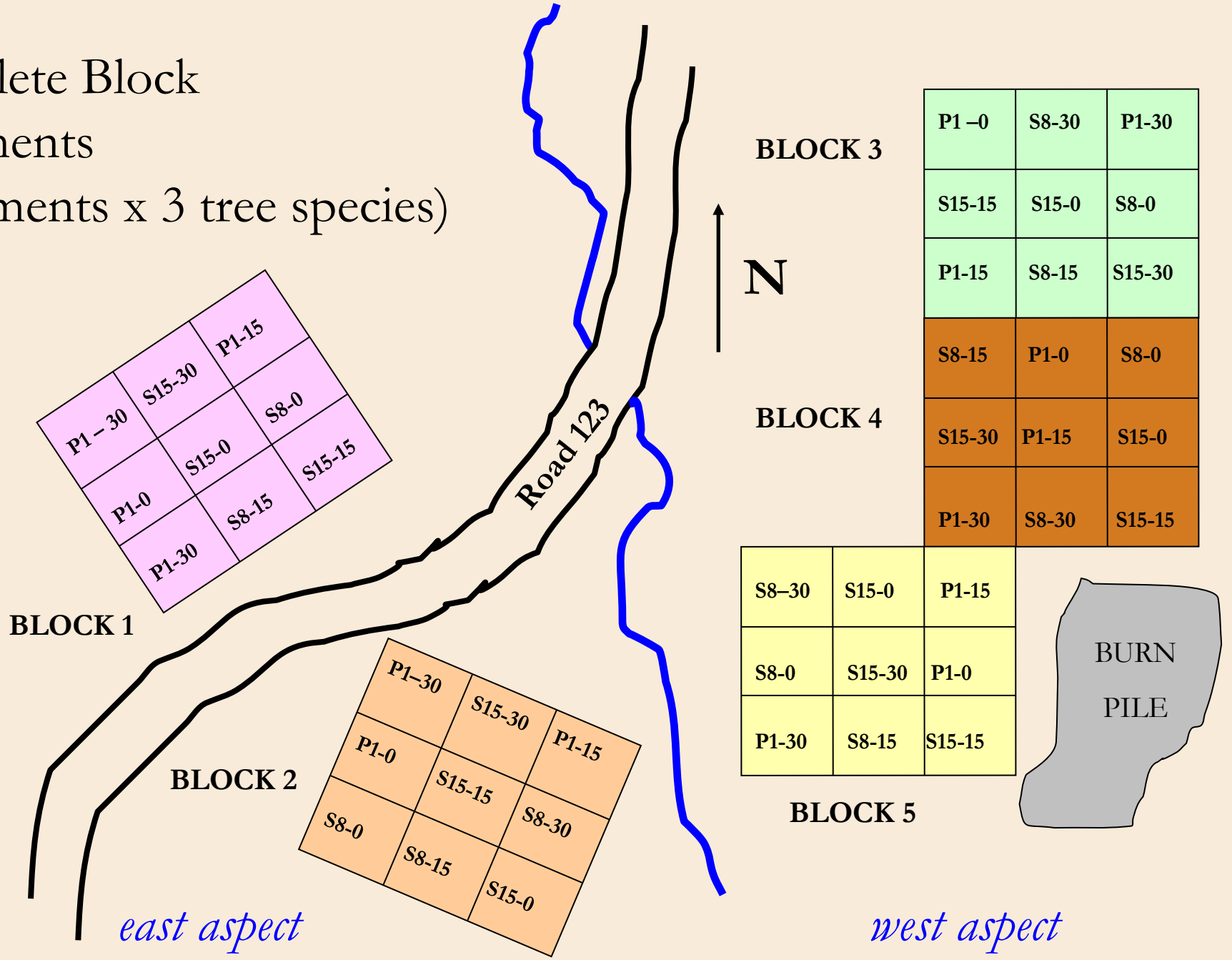
25 trees per plot



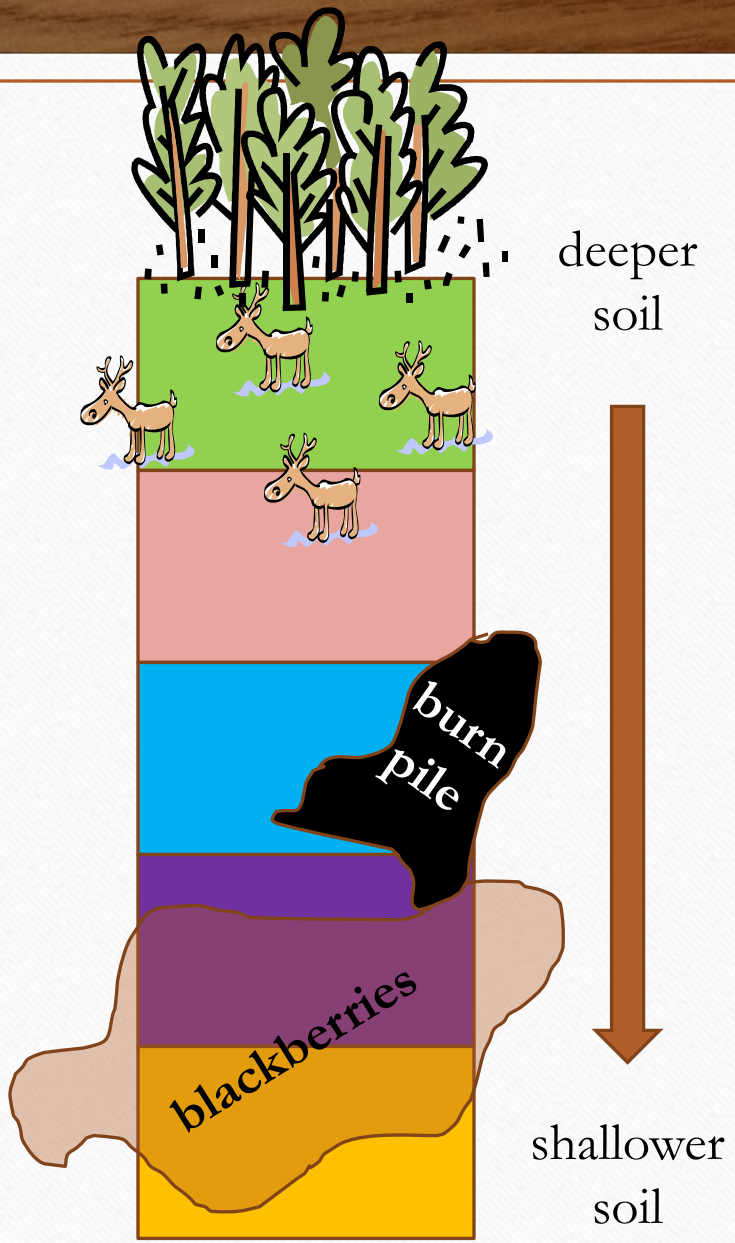
Randomized Complete Block

- Treatment plots are grouped into blocks
  - Conditions among blocks can vary significantly
  - Conditions within each block should be relatively uniform
  - Every treatment is randomly assigned within each block

Randomized Complete Block with factorial treatments (3 veg control treatments x 3 tree species)

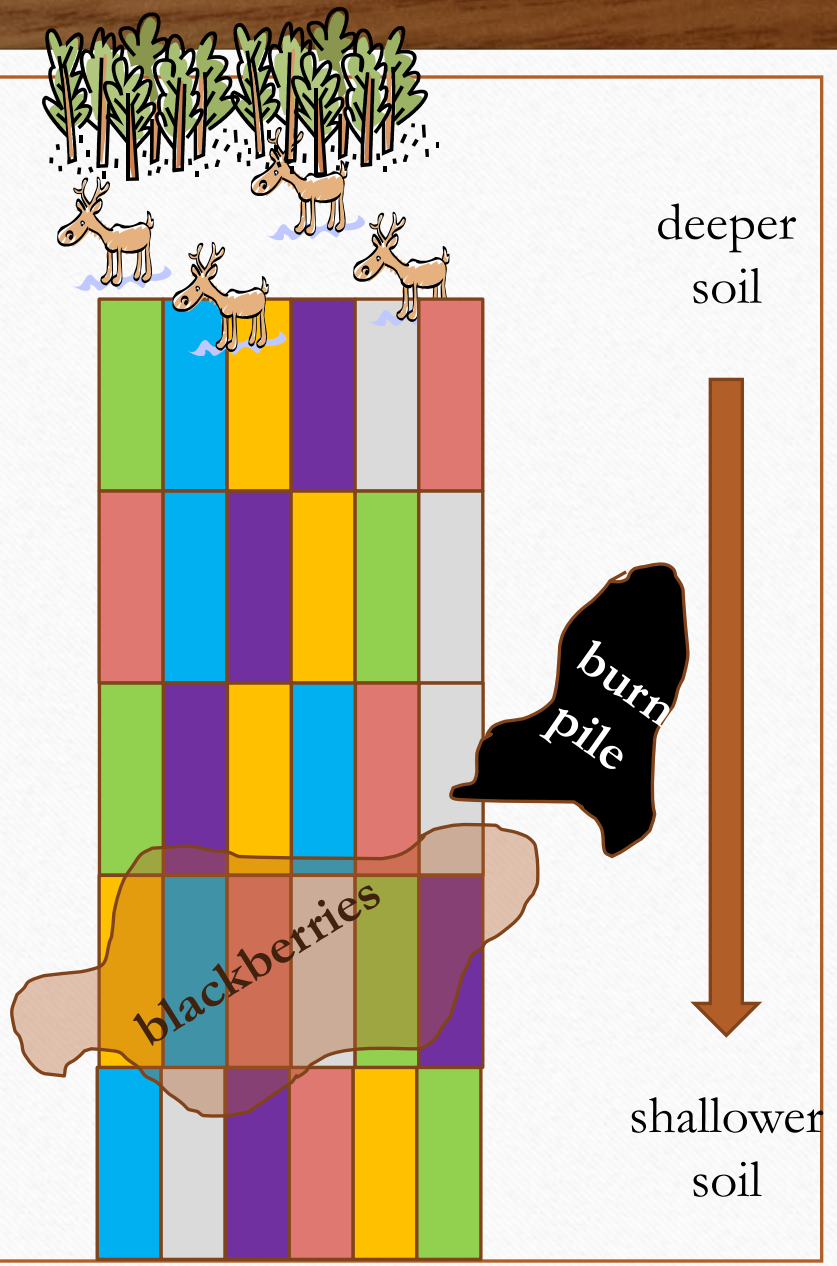


What could Cowboy Joe do differently?



- Control excess variation
  - Replicate and randomize to eliminate confounding and bias
  - Make sure conditions within each replication are fairly uniform (e.g., burn pile or blackberry patch if it can't be avoided)
- Add a control treatment
  - The usual method and/or no treatment

Not "operational" but eliminates "noise"



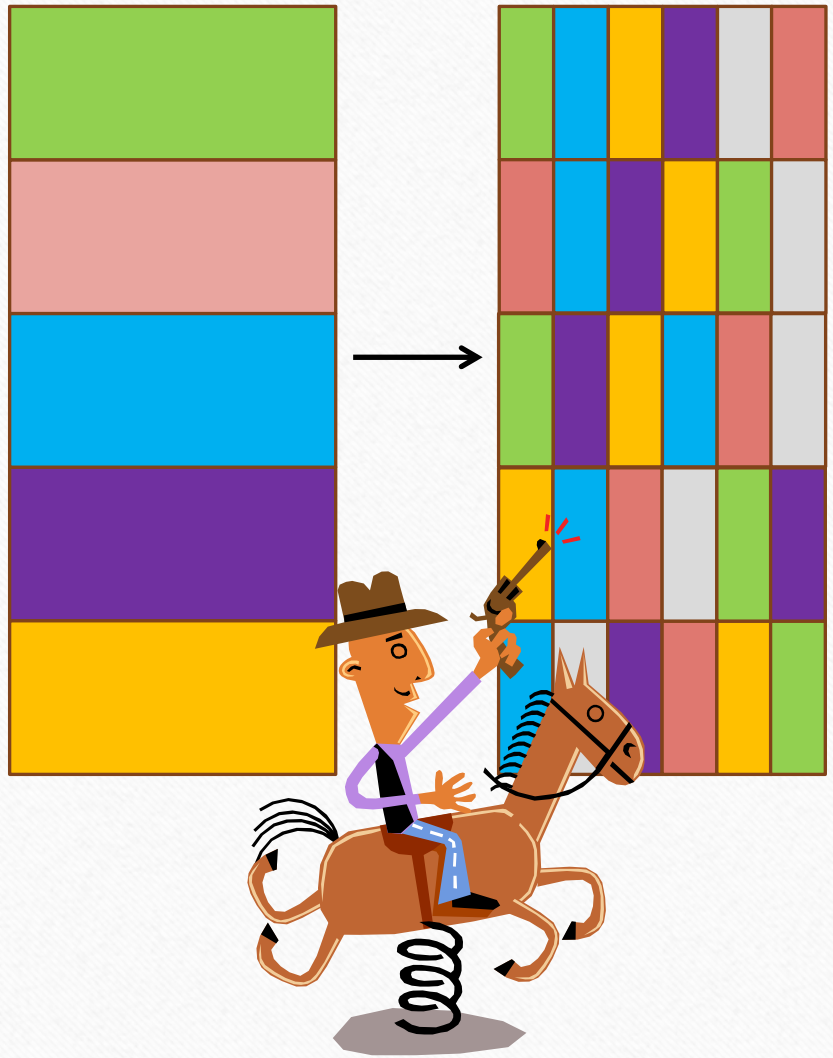
Cowboy Joe's study design is a Randomized Complete Block

- Five blocks (replications)
- Six treatments (5 + control) randomly assigned within each replication
- Each block has 150 seedlings (25 per treatment replication)

A	C	E	D	X	B	Block 1
B	C	D	E	A	X	Block 2
A	D	E	C	B	X	Block 3
E	C	B	X	A	D	Block 4
C	X	D	B	E	A	Block 5

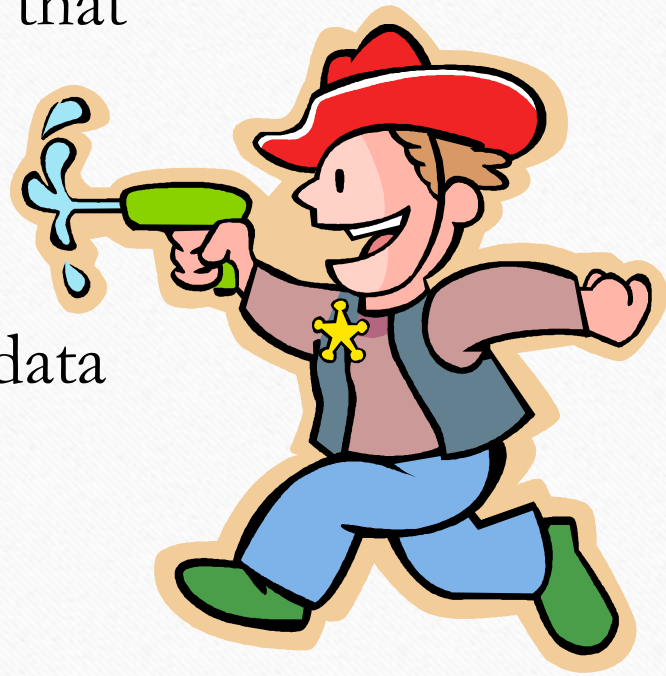
Proper design does not have to cost more or take a lot more time….

- For, Cowboy Joe, the revised design uses the same amount of space and seedlings and just a little more time to randomize, apply treatments, and maintain the plots
- Furthermore, the original design produced confounded data and was a 100% waste of time and resources



More Tips for Conducting Successful Studies

- Prepare a detailed study plan
- Install the study carefully – protect from anything that can add bias, confounding, or excess variation
- Identify the study area with stakes/flagging/tags
- Create a good map of the study area
- Avoid bias/confounding/excess variation during data collection
- Keep data in a spreadsheet
- Record everything and take a lot of photos



For more details…

Haase, D.L. 2014. Beyond Cowboy Science: Simple Methods for Conducting Credible and Valid Research.

Tree Planters' Notes 57(2): 32-43.

Available at: www.RNGR.net


Questions?
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