Adaptive survey designs for monitoring animal and plant distributions

ASEARC CONFERENCE
University of Wollongong
2&3 December 2008

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Outline of Presentation

- Unequal probability sampling
- Adaptive sampling
- Two stage sampling
- Designs for rare and clustered populations
- Case study for weed surveillance in Southland, New Zealand

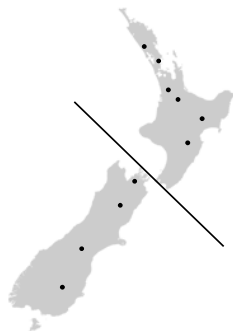# Equal probability sampling

- Random sampling

Equal probability sampling

- Random sampling
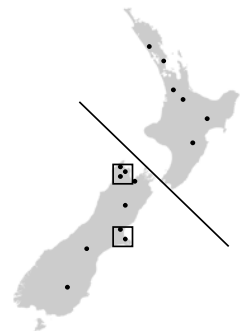 - Can get a really bad sample

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Unequal probability sampling

- Stratified sampling
  - Sample weights
  - Sample fraction
  - Selection probability
 - How much area each sample point represents

Sample weight

Unequal probability sampling

- Unequal probability sampling
  - Strata don't need to be contiguous
  - Anything can be used to stratify

Sample weight

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Adaptive sampling

- Unequal probability sampling where the decision on the final sample weight is made as new information comes to hand
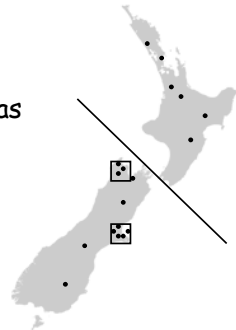
Sample weight

Two Stage Sampling

Primary Sample Units

Two Stage Sampling

Primary Sample Units

Two Stage Sampling

Secondary Sample Units within Primary Units

Unequal Probability Adaptive Designs
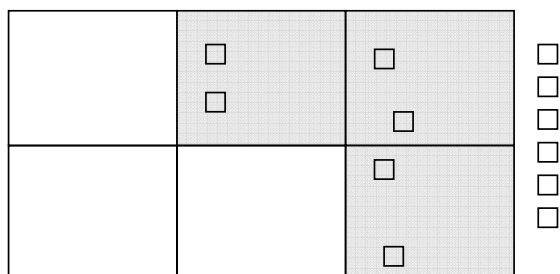
Rare and clustered populations

Unequal Probability Adaptive Designs
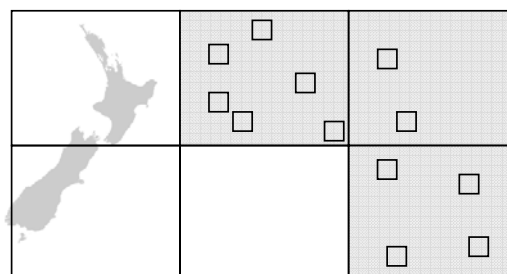
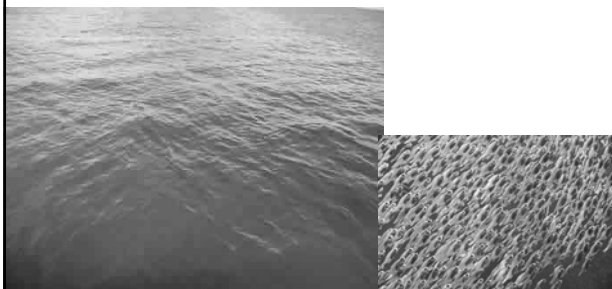Rare and clustered populations

Two Stage Adaptive Sampling

Two Stage Adaptive Sampling
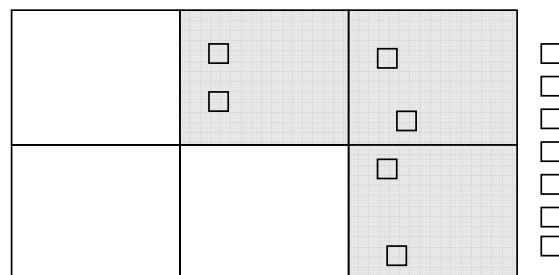
Chris Francis - NIWA
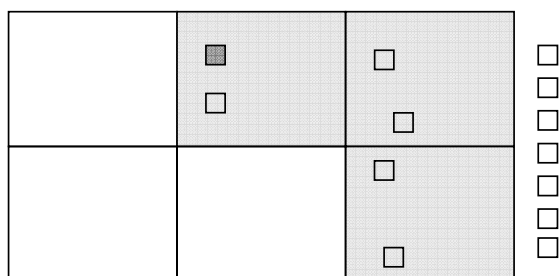

Unequal Probability Adaptive Designs

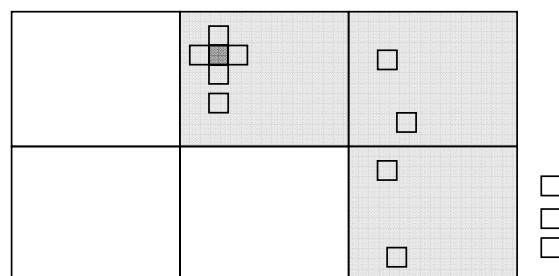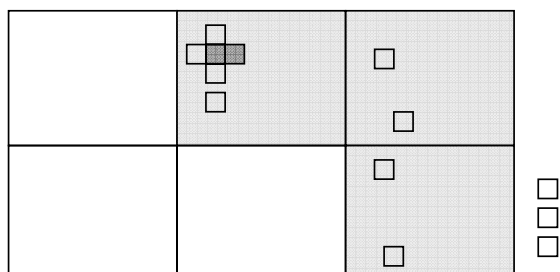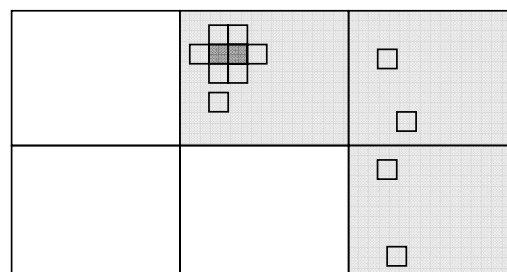Directing survey effort where the animals are.

Two Stage Adaptive Cluster Sampling

Two Stage Adaptive Cluster Sampling

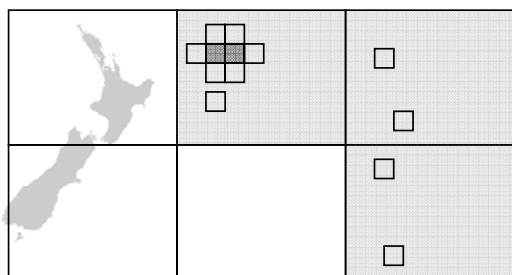Two Stage Adaptive Cluster Sampling

Two Stage Adaptive Cluster Sampling

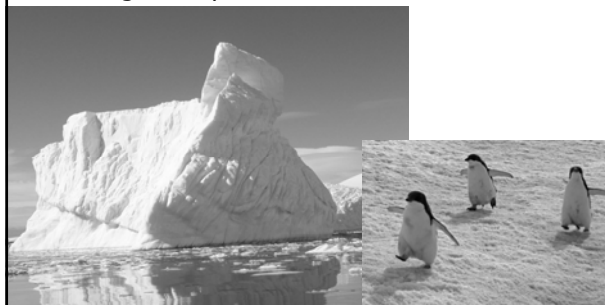## Two Stage Adaptive Cluster Sampling

Two Stage Adaptive Cluster Sampling

Mohammad Salehi & George Seber

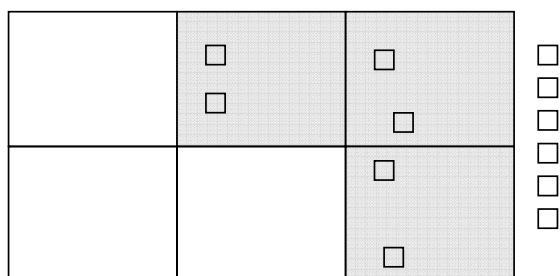## Unequal Probability Adaptive Designs

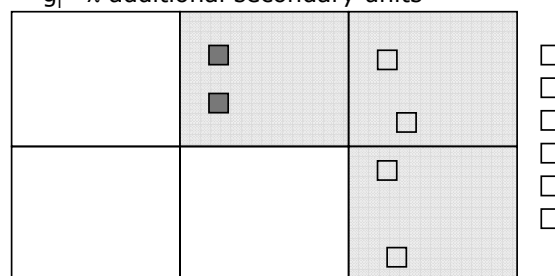Directing survey effort where the animals are.

Adaptive Two Stage Sequential Sampling
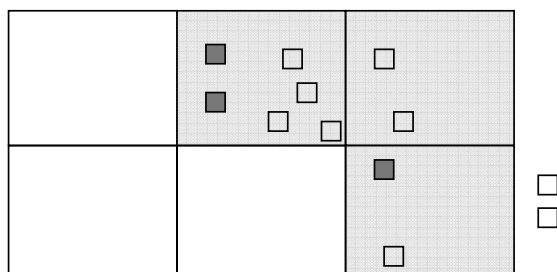
Initial sample within Primary Units

Adaptive Two Stage Sequential Sampling

Additional secondary units are allocated if $y_{ij} > C$
$g_i \cdot \lambda$ additional secondary units

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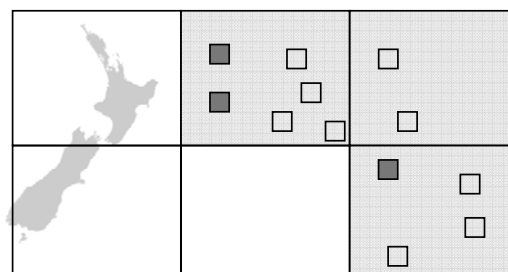
Adaptive Two Stage Sequential Sampling

$g_i \cdot \lambda$ additional secondary units

Adaptive Two Stage Sequential Sampling

Brown, Salehi, Moradi, Bell and Smith

Unequal Probability Adaptive Designs

Directing survey effort where the plants are.
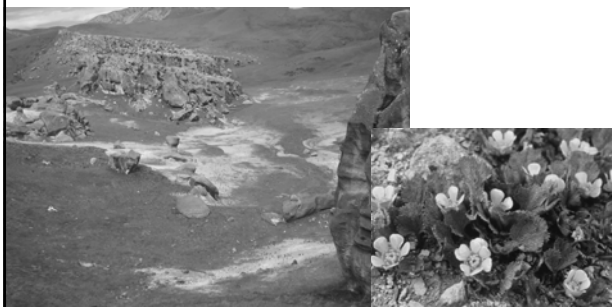
Adaptive Two Stage Sequential Sampling

Blue winged teal

Adaptive Two Stage Sequential Sampling
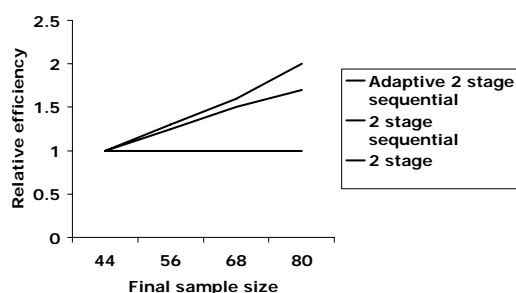
Unequal Probability Adaptive Designs for Weeds

- Direct survey effort where plants or animals are
- Divide up the area
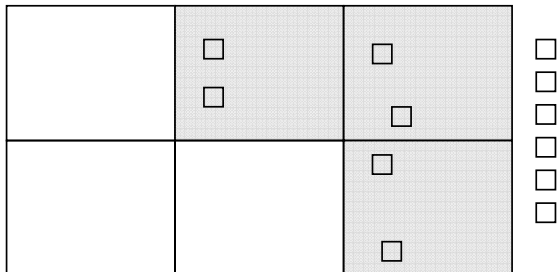 - Strata or primary sample units
- Use an adaptive design
  - Have a lot of additional effort to allocate to where the species is found
  - Maximise flexibility for allocating additional effort

Adaptive Two Stage Sequential Sampling

Initial sample within Primary Units

Southland

Southland Region, NZ

Early surveillance of Non-indigenous Invasive plant Species (N.I.S.) or "weeds"

Spatially balanced survey design using GRTS

- Unequal probability design
- Reporting
  - Proportion of Southland occupied by weeds
  - Estimates of weed density by species
- 5 year panel design

Southland

- 3,000,000+ hectares
- 100,000- people
- Farming, forestry, & horticulture
- Fiordland & Rakiura N.P.
- Indigenous tussock grasslands, rugged coast, glaciers, alpine forest, wetlands, rivers, lakes
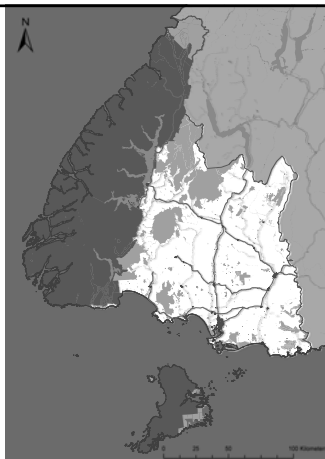
Southland
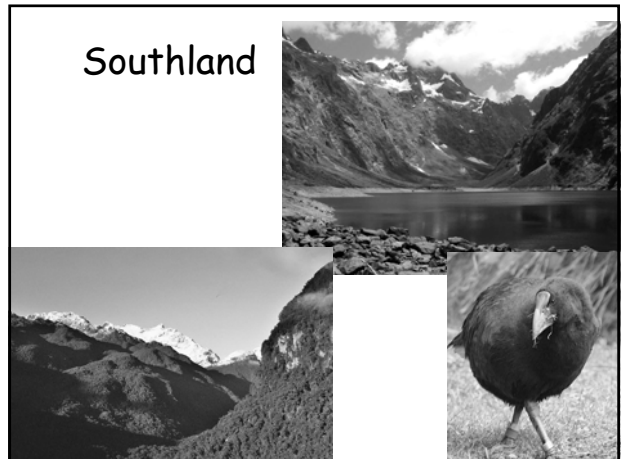
Southland
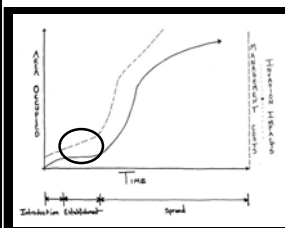
- Weed cost curve

Early detection/success:
eradication, cost effective
Pampas grass, stagwort in
NZ islands

- Karoo thorn (Acacia karoo) in Western Australia

Spatially Balanced Survey Design using GRTS

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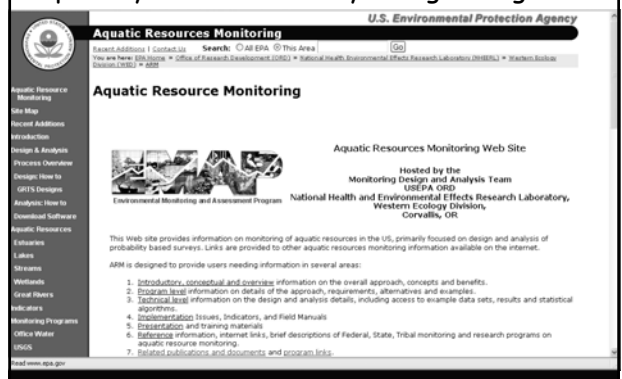
Spatially Balanced Survey Design using GRTS

- GRTS is useful for large scale environmental surveys

Spatial Balance: 100 points
Voronoi polygons

| Uniform Sample | GRTS Sample | Grid Sample |

small ← polygon area → large
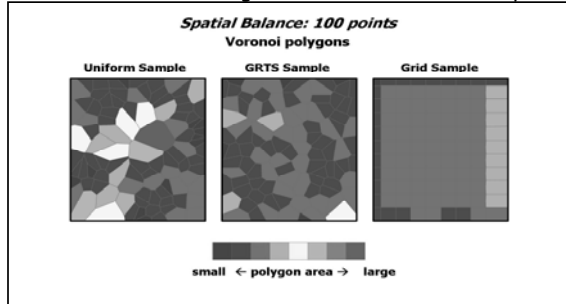
Spatially Balanced Survey Design using GRTS

```
design = list(None=list(panel=c("Year One"=200, "Year Two"=200,
                                 "Year Three"=200, "Year Four"=200,
                                 "Year Five"=200), seltype="Equal", over=700))

design = list(None=list(panel=c(Panel=100), seltype="Equal", over=70))

sites <- grts(design,
        DesignID="SthHwy07",
        type.frame="area",
        src.frame="shapefile",
        in.shape='C:/studyUC/GIS2/Southland/southland_hwybuff',
        att.frame=att,
```
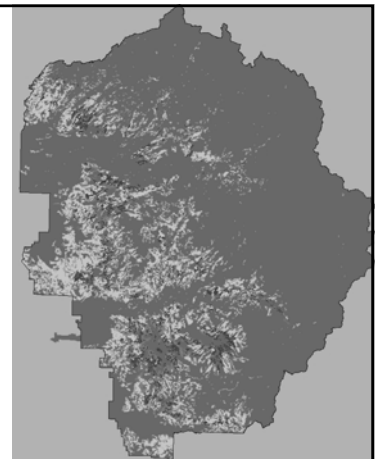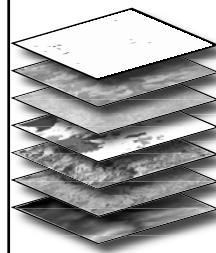
- Survey design with R-GRTS: R code
- Other tools available: S-draw and RRQRR
- ArcGIS Interface

Spatially Balanced Survey Design using GRTS

- GRTS is ... l surveys like wee...
  - Strati...
  - Equal, ...ion
  - Over s...sed
  - Panels...
  - Two st...
  - & Input ...a) shapefile

- Survey ...
- Other t...
- ArcGIS Interface

GIS

GRTS in Southland

- 5 year plan
- Large, diverse area
- Partial replacement Year 6[+]
- Potential for change in sample site number over time

- Unequal sample probability
  - Roads & waterways as areas of more intense effort;
  - But still want to estimate for whole region.

- Excluded urban areas (GRTS accommodates voids)

Unequal Probability Adaptive Designs for Weeds

Year	Site											
	A	B	C	D	E	F	G	H	I	J	K	L
1	√	√	√									
2				√	√	√						
3							√	√	√			
4	√	√								√		
5				√	√						√	
6							√	√				√
...												

Problems/Complications - Solutions

Plan site visits to meld GRTS order & travel
- Fill in gaps (of grts order)
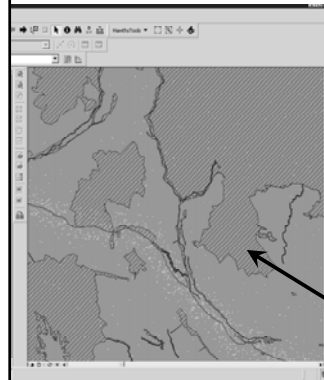
Difficulty obtaining permission from landowners
- Need to track this information and assess its impact on results

Not all sites visited by end of season (weeds seasonal growth & id)
- Reassignment of probabilities
- Complexity of implementing: Requires planning and training of field crews on importance of completing sites.

Future Directions

- Simulate models of spread & distribution
- Compare adaptive unequal designs
- Incorporate increasing knowledge
- Include the cost of missing weed occurrence vs cost of control (including cost of road and field travel) in high/low conservation areas

Conservation Land

Acknowledgements:

Tony Olsen, US EPA
NZ Institute of Mathematics and its Applications Bio-Protection Research Centre (NZ)
Environment Southland

Thank you!