Unit 6, Search sensors and Search tactics.
Date Last Updated: February 21, 2020

This presentation is not a complete manual for search and rescue response. The materials are not meant to replace field training by competent search and rescue leaders or to replace actual experience. NEWSAR and the authors and contributors do not endorse any specific equipment mentioned or shown in this program. The authors, contributors, and NEWSAR take no responsibility for the use of this guide or the information contained within. The authors, contributors, and NEWSAR take no responsibility and cannot be held liable for statements made by instructors who use this presentation. It is the duty of every community, organization, volunteer group, and agency, to obtain the knowledge, skills, and proficiency to perform and maintain effective search and rescue management and operations. The information presented in this presentation serves as part of a beginning outline and body of knowledge for proper search and rescue respons programs at the community level.
A course presented using this material may only be represented as a NEWSAR course, and may only use NEWSAR marks if presented by an authorized NEWSAR instructor under the auspicies of NEWSAR. No authorization for the use of NEWSAR marks is given or implied by this document.

Search Crucials

- Search is an Emergency
- Search is a classic mystery
- **Search for clues not just the subject**
- Know if the subject leaves the search area
- **Close grid search as a last resort**
- Manage by objectives
- Search management is information management

Highlighting two search crucials: Search for clues and the subject, grid search as a last resort.

Search Sensors and Tactics

All about the distinction between resources that are only likely to detect the subject, and those that are likely to detect both clues and the missing subject.

What can you see?

Looking beneath the bush.

How about here?

Footprint: Transfer on the leaf, pattern (straight lines from the pattern on the sole, color change, impressed pine needles, etc...

Ground Search Resources

- Clue Aware Searchers
  - Volunteer SAR organizations
  - Civil Air Patrol
  - SAR trained Police, Fire, CERT personnel
  - Signcutters
  - Search Dogs
  - Horses
- Subject Finders
  - Firefighters (without SAR training)
  - Technical rescue resources (without SAR training)
  - CERT teams (without SAR training)
  - Spontaneous volunteers

Ground searchers clue aware and subject finders.

Search crucial: Search for clues and the subject.

Question: Why do spontaneous volunteers need to be managed? Discuss.

External Influences

There are also external influences to be managed.

Managing external influences (including politicians and psychics) is a concern of search managers.

Other Resources

- Search Managers
- Communications
- Hazardous Materials Response (Fire Service)
- Information Resources
- Sensors
  - Thermal Imaging
  - FLIR
  - Light Amplification
- Air resources
  - Helicopters, Drones, Aircraft

Other resources that can be brought in to the search.

Incident management resources, particularly those trained and experienced in search management.

Where can these sorts of resources be requested from?

What other resources might be available to support a search?

[Image is a NightSun spotlight on a Boston Medflight helicopter]

Fire Service Resources

- Wildland firefighters (local terrain knowledge)
- People to go door to door with flyers, resources for Containment
- Lights (scene lighting, attraction)
- Rehabilitation (mist fans)
- Communications
- Thermal imagers
- Technical rescue (high angle, confined space, water (wetsuits, drysuits))

Plenty of important resources in the fire service.

But not firefighters tramping through the woods in full structural firefighting turnout gear...

Water rescue and ice rescue resources may be effective assets to help in searching wetlands.

Then there are mechanized resources for transport and search. We'll come back to these.

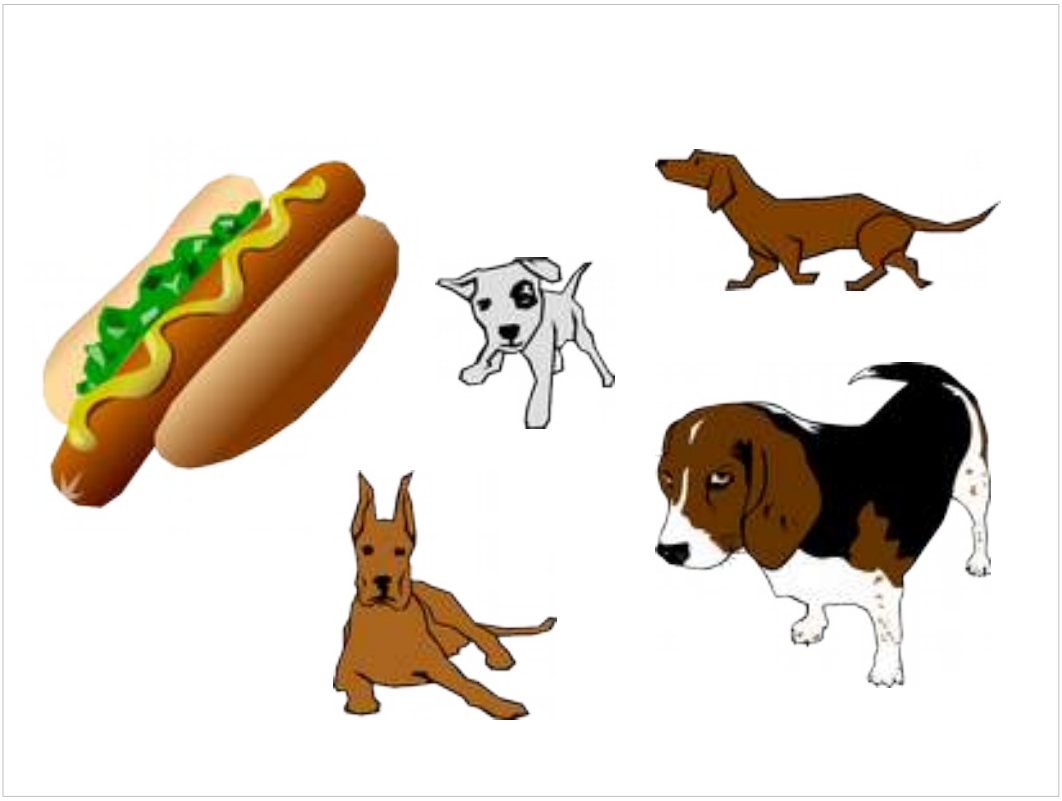
Are these typically clue finders or subject finders?

Then there are Search dogs.

Typed Resources

- Call out the dogs....

In asking for search resources, you need to be specific.



What sort of dogs?

FEMA Typed Canine SAR Resources

- Canine Search and Rescue Team – Avalanche Snow Air Scent
  - Type I, Type II
- Canine Search and Rescue Team – Disaster Response
  - Type I, Type II, Type III, Type IV
- Canine Search and Rescue Team – Land Cadaver Air Scent
  - Type I, Type II, Type III, Type IV
- Canine Search and Rescue Team – Water Air Scent
  - Type I, Type II, Type III, Type IV
- Canine Search and Rescue Team – Wilderness Air Scent
  - Type I, Type II, Type III, Type IV
- Canine Search and Rescue Team – Wilderness Tracking/Trailing
  - Type I, Type II, Type III, Type IV

FEMA, as part of NIMS, has developed resource type descriptions for SAR.

Need to understand the general capabilities and how they interact with ground searchers.

Canines

- Wilderness Air Scent
- Trailing
- Tracking
- HRD
- Water
- Avalanche
- Disaster
  - Live Find
  - HRD

Some canine disciplines relevant to search.

Dogs may be cross trained or single discipline.

The bloodhound.

Or, tracking/trailing dogs in general.

Needs a scent article (collected by the handler) with the subject's scent on it.

Seeks to acquire and follow the subject's scent trail.

Detect the scent from skin cells shed by the subject, and the odors of damaged vegetation and disturbed ground.

Here's a trailing dog at work.

Tracking generally defined as working right on the track of the subject, trailing generally as more loosely following the scent left by the subject.

Tracking and trailing dogs work on lead. They are presented with a scent article carrying the scent of the missing subject, acquire the trail, and follow the scent of that particular subject.

Hint that this dog is trailing rather than tracking is the nose up posture.

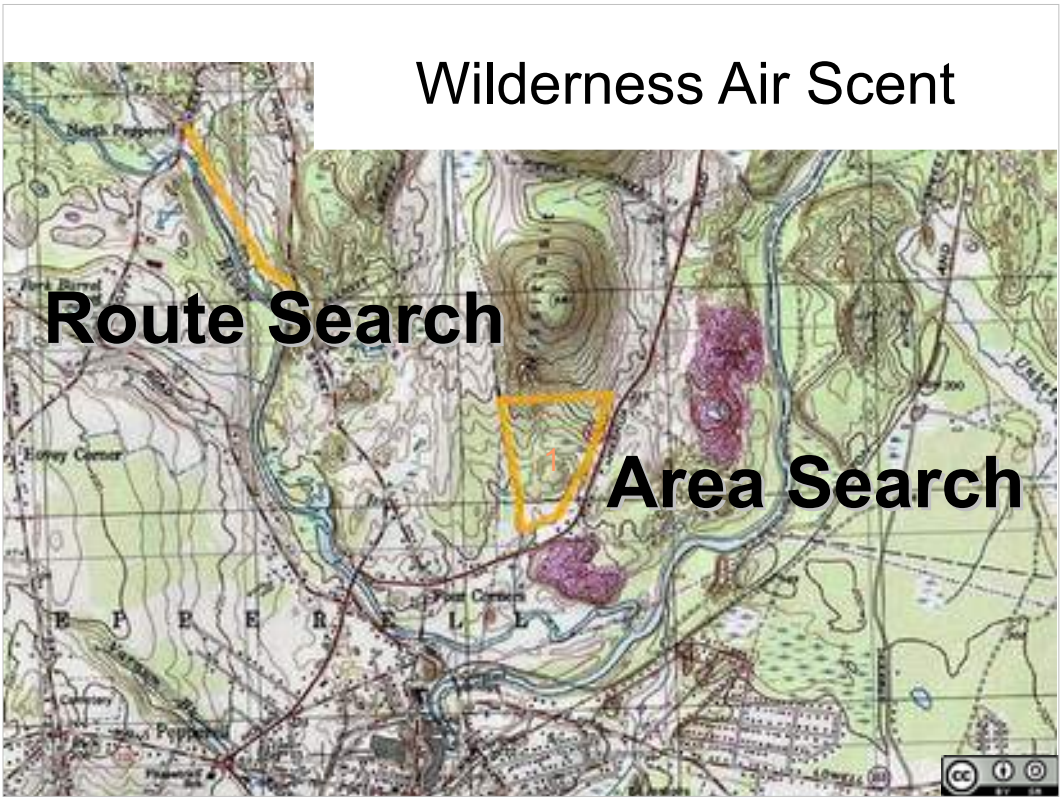
Then there are Wilderness Air Scent canines.

Not scent specific: Trained to find any person in the search segment.

Detect a plume of scent coming off of a live human.

Work off lead, get into the scent of a human, follow it to source, then return to tell the handler.

Wilderness Air Scent canines typically have a trained indication behavior of either stay and bark at the subject, or return to the handler, perform a trained behavior and bring the handler back to the subject (a refind).



Can efficiently search both areas and routes (trails, drainages, travel corridors).

Then we have humans that track humans.

Determining Direction of Travel

- Signcutters
  - Tracking from IPP
  - Binary Search
  - Track Traps
- Tracking Dogs
- Trailing Dogs
- Clues

Some resources are able to identify the subject's direction of travel.

As we saw earlier, for some subject categories, direction of travel is very predictive of find location.

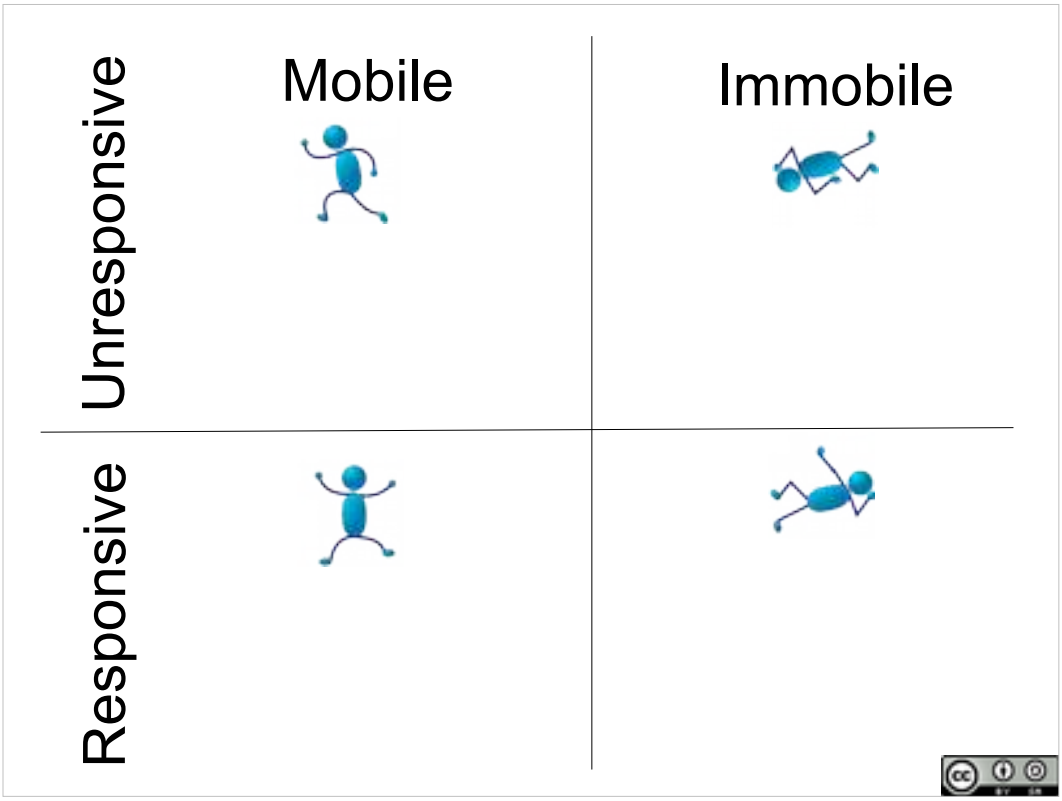
Tactics

- Direct (=Active)
  - Go and find the subject.
- Indirect (=Passive)
  - Make the subject come to you.

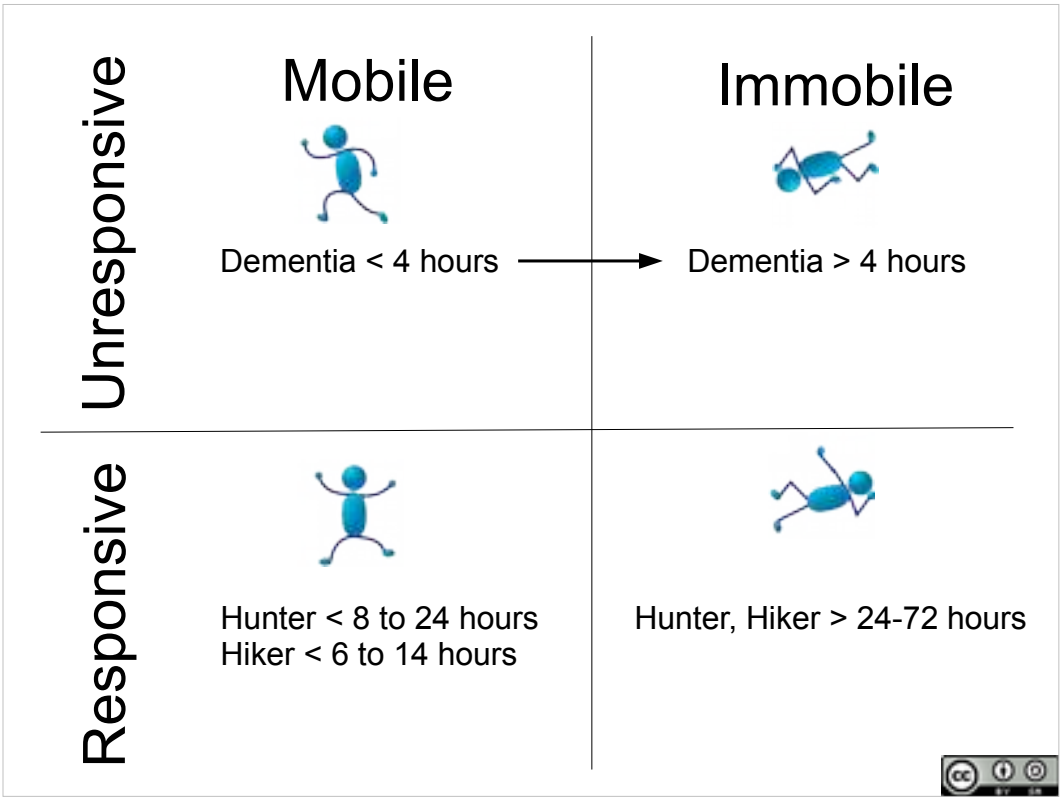
We talked about this before.

Tactics in a search – direct and indirect.

What are some examples of each?



Tactics influenced by likely responsiveness and mobility of the subject. Indirect tactics won't help much for an immobile unresponsive subject.



Where a subject falls in this matrix changes over time.

In general: change from mobile to immobile.

Different subject categories have different statistical profiles in how rapidly they tend to become imobile.

Responsive?
Sound Sweep

- Stop
- Pause
- Call Subject's name
- Wait and **listen** (important part)
- Continue

Sound Sweep:

Key part of calling out for a possibly responsive subject is waiting and listening to see if they answer.

Not: “Johnny, Johnny, Johnny, Johnny....”

Direct or indirect tactic? (direct, you are doing it while actively searching for the subject).

How does this differ from attraction? (you are doing it while actively searching for the subject, not making noise and waiting for the subject to come to you).

Tactics

- Direct/Active

  Go find the subject.
  - **Type I to Type IV search (human, canine, equine)**
  - Aerial search

- Indirect/(Passive)

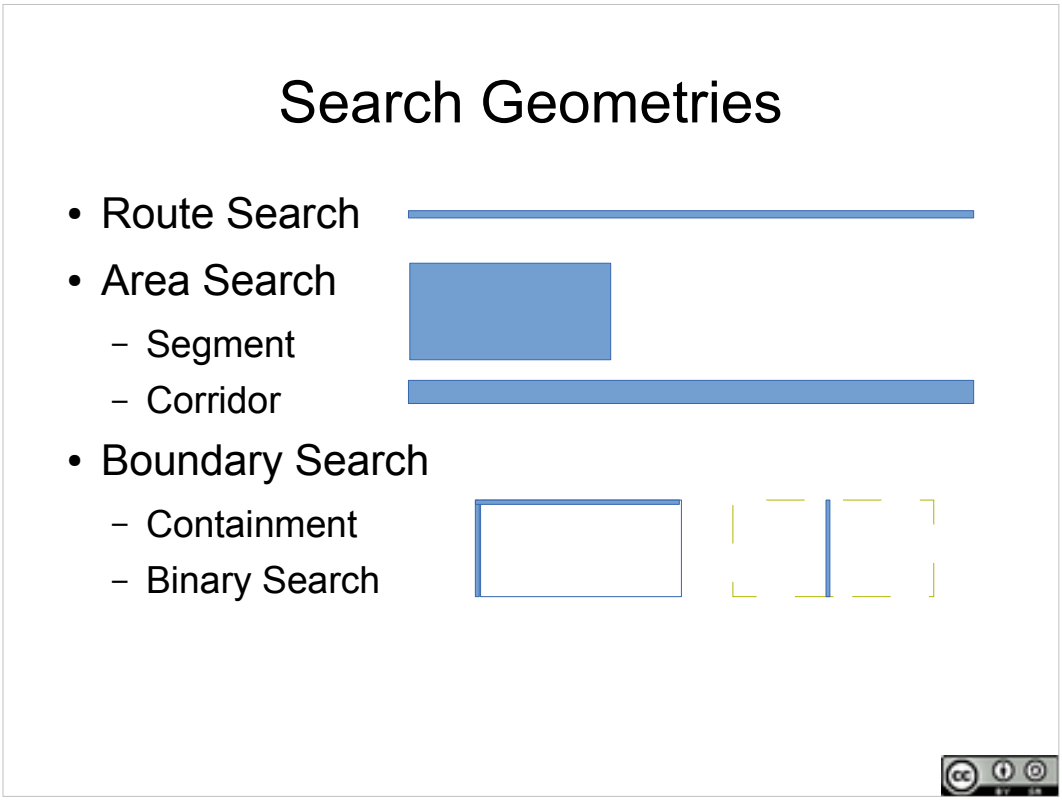
  Make the subject come to you.
  - Investigation
  - Containment
  - Attraction
    - Sound
    - Lights
  - "Limited Continuing Search"

Some direct and indirect tactics.

Not mutually exclusive. Search managers will use both direct and indirect tactics at the same time.

Investigation is key in all searches.

Lets look in more detail at some Direct search tactics.



Search resources can be tasked to search:

Routes: Trail/route searches on likely travel routes. Search along a linear travel feature.

Areas: Search an area (which could be a long narrow area along a travel corridor (like up a valley floor)).

Or searches along **boundaries** of segments – typically with signcutters.

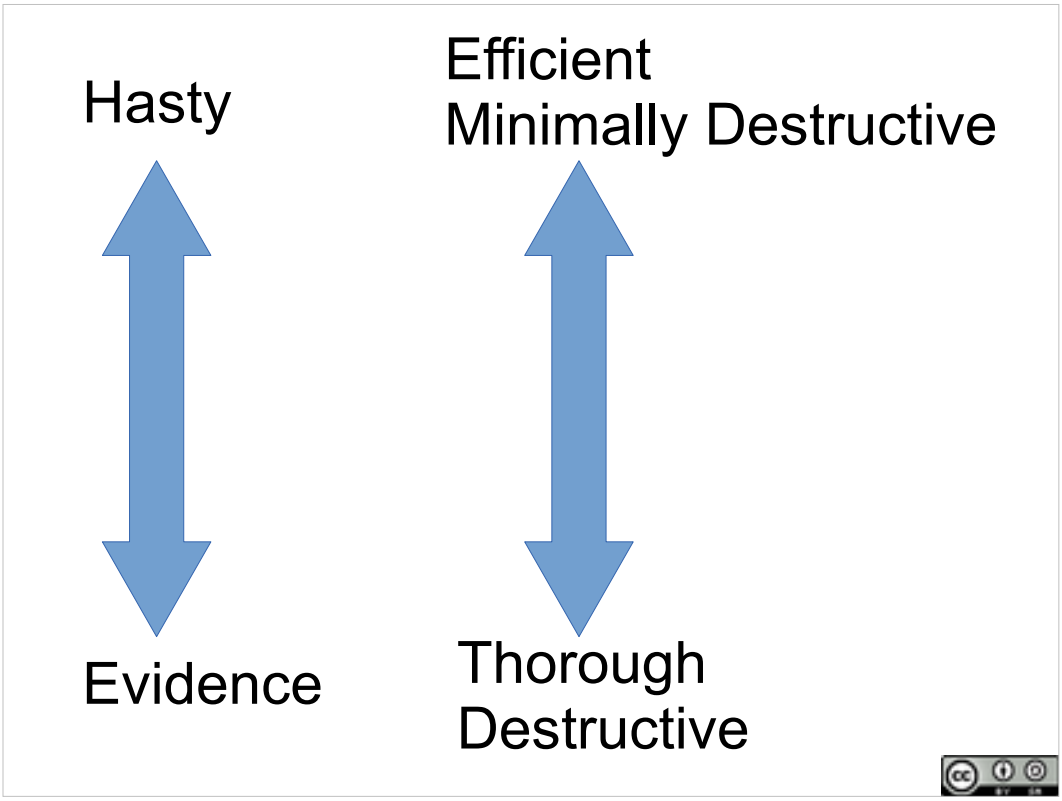
As we talked about (in the ICS planning P) direct tactics in a search often proceed from a focus on route (hasty) searches to area searches.

Types of Ground Search

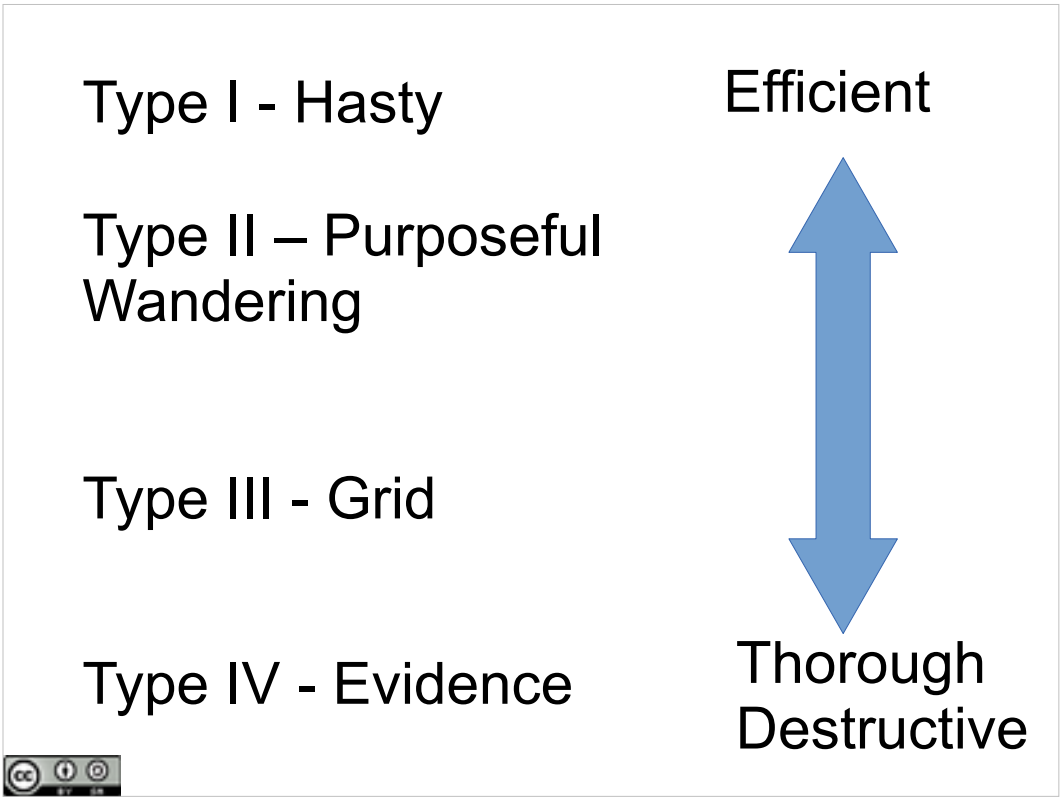
- **Type I**
  - Hasty tasks: speed – trails, high probability and high risk areas.
- **Type II**
  - Small teams, loose grid - efficiency
  - Clue finders with critical separation
- Type III
  - Grid search – Thorough, slow, **destructive**
- Type IV
  - Evidence Search

We can divide ground search into 4 types.

These vary in efficiency, thoroughness, and destructiveness.



Type I search is most efficient, and least destructive. Type IV search is least efficient, most thorough and most destructive.

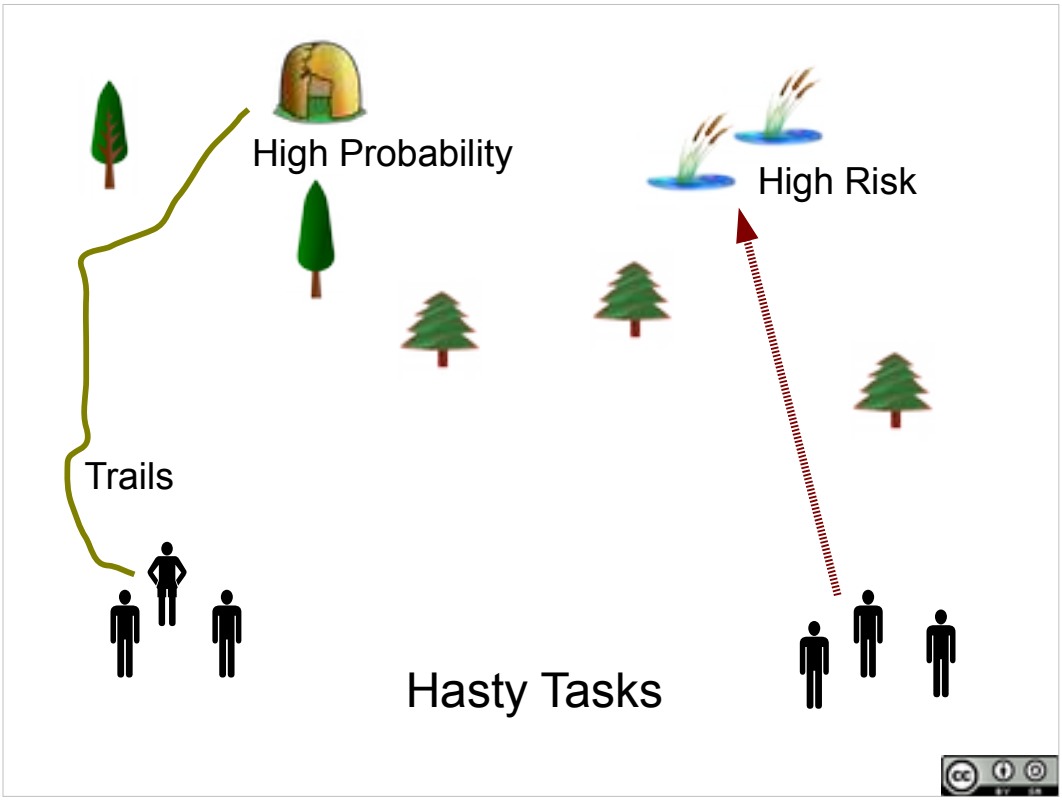


So there's a range from

Hasty – efficient

to

Evidence search – thorough and destructive.



Type I search – hasty (meaning efficient, not careless) search of areas of high probability or high risk.

High probability is also often trails and travel corridors.

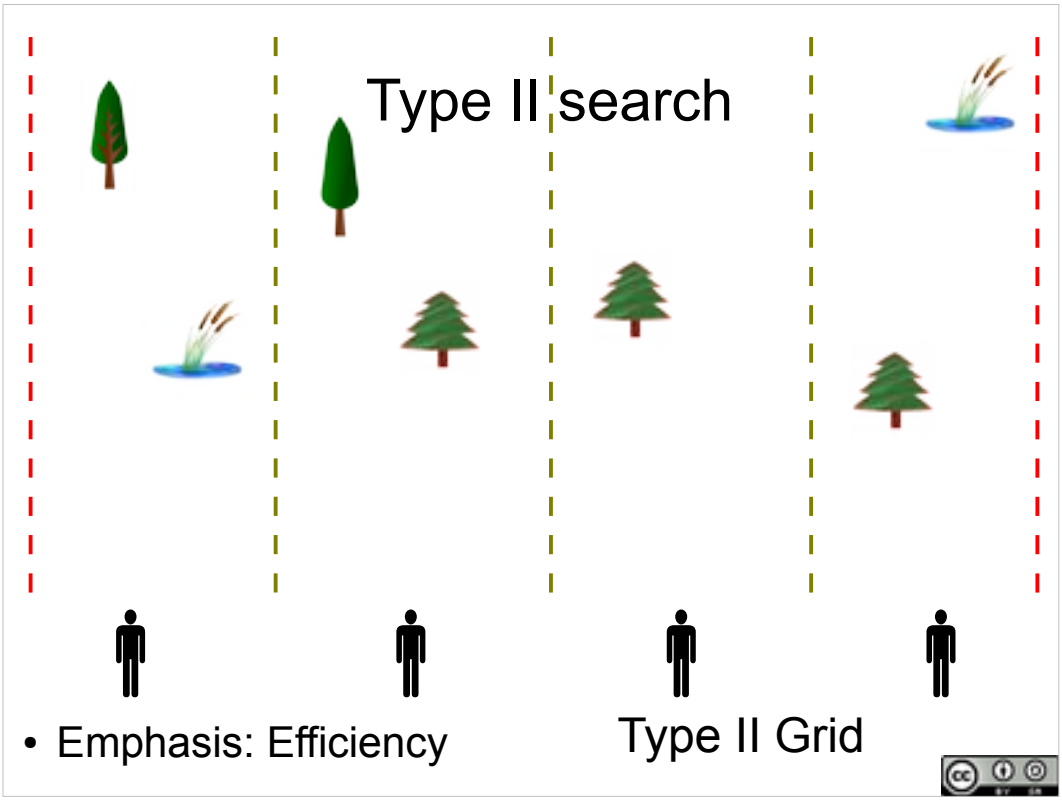
High probability may be particular attractors or structures.

Special attention should be paid to enclosures like refrigerators, freezers, and the interior of parked vehicles where limited breathing air may place the child at even greater risk.

NCMEC Model Missing Children's Policy

Hasty tasks to places of high risk – where if the subject is there now, they are at risk,and finding them may make a difference. Vehicles, abandoned vehicles, refrigerators/freezers, water and swamp margins (entrapment, hypothermia), etc.

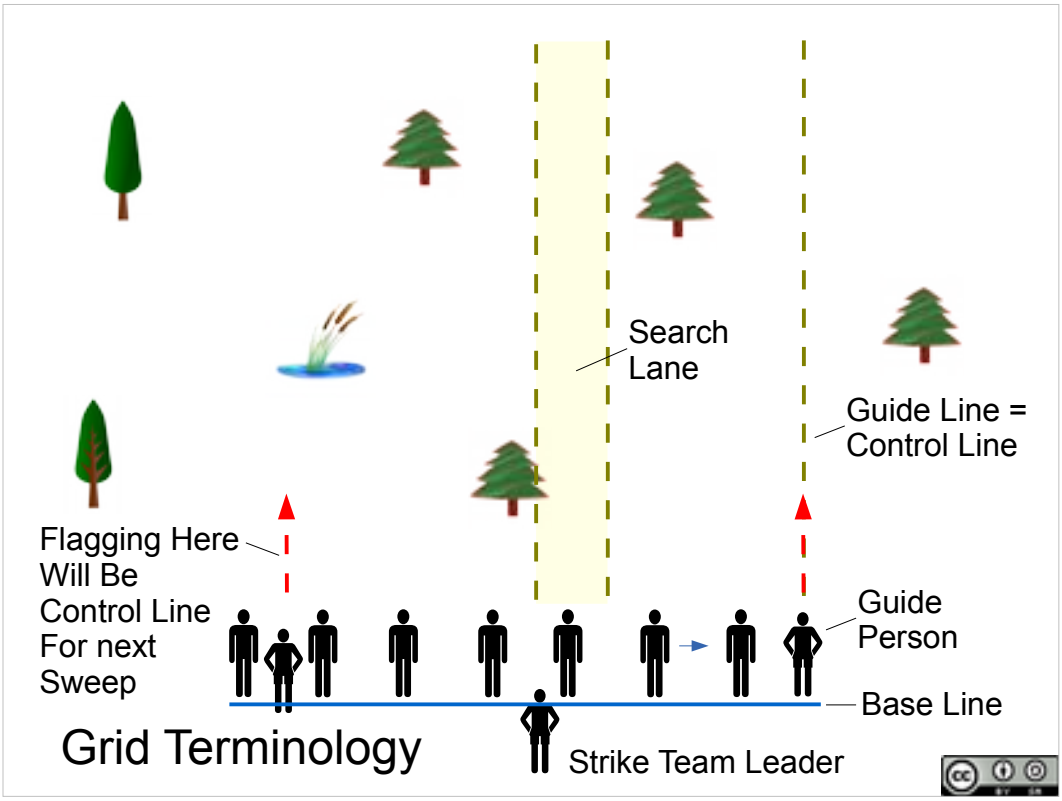
Here's a hasty task searching along a shoreline.



Then, moving up in thouroughness: Type II search.

Open grid search with clue aware searchers.

Everyone has a search lane.



Type II search is a type of grid search. Search lane is a concept from grid search. So, let's describe a grid search.

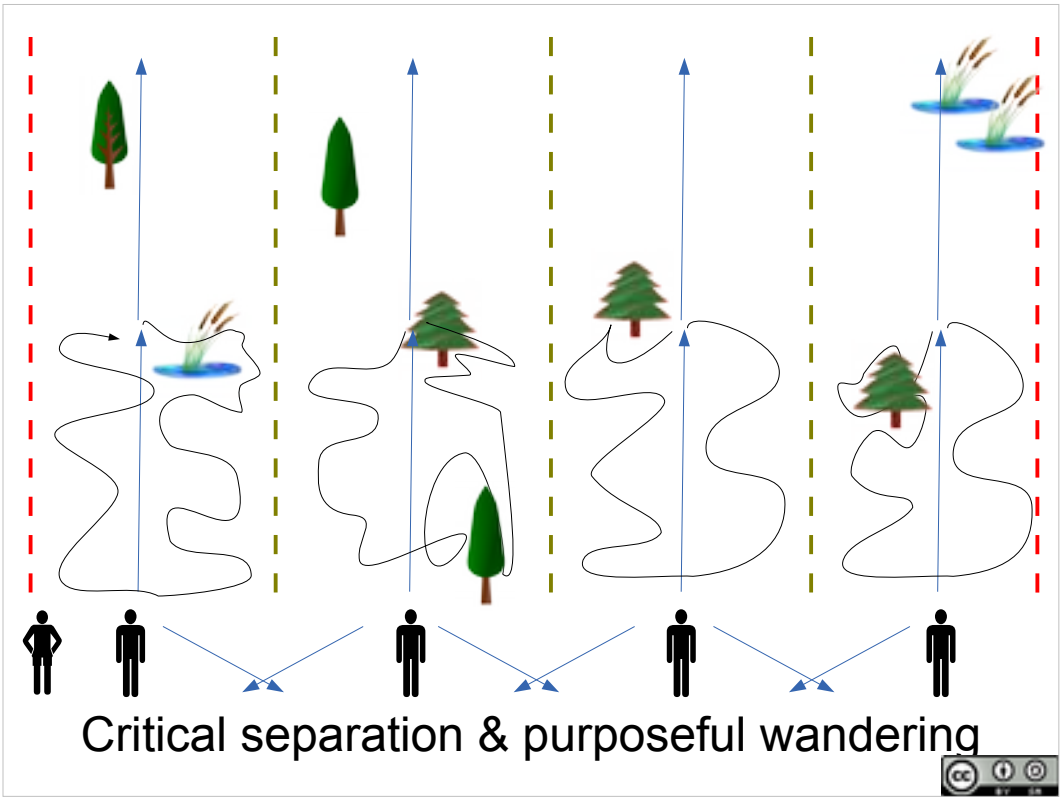
Each searcher has a search line.

Each searcher starts on the base line.

Each searcher maintains distance from a guide person on the guide/control line.

Far end from the control line flags for the control line on the next sweep.

Maintain Span of Control: Someone needs to be in charge, and they need to be able to control the grid line.



In a Type II search, Searchers can wander purposefully in their search lanes.

The searchers are responsible for staying in their search lane and staying together as a coherent grid line, but trained searchers can purposefully wander to go look behind a tree, under a patch of thick brush, etc.

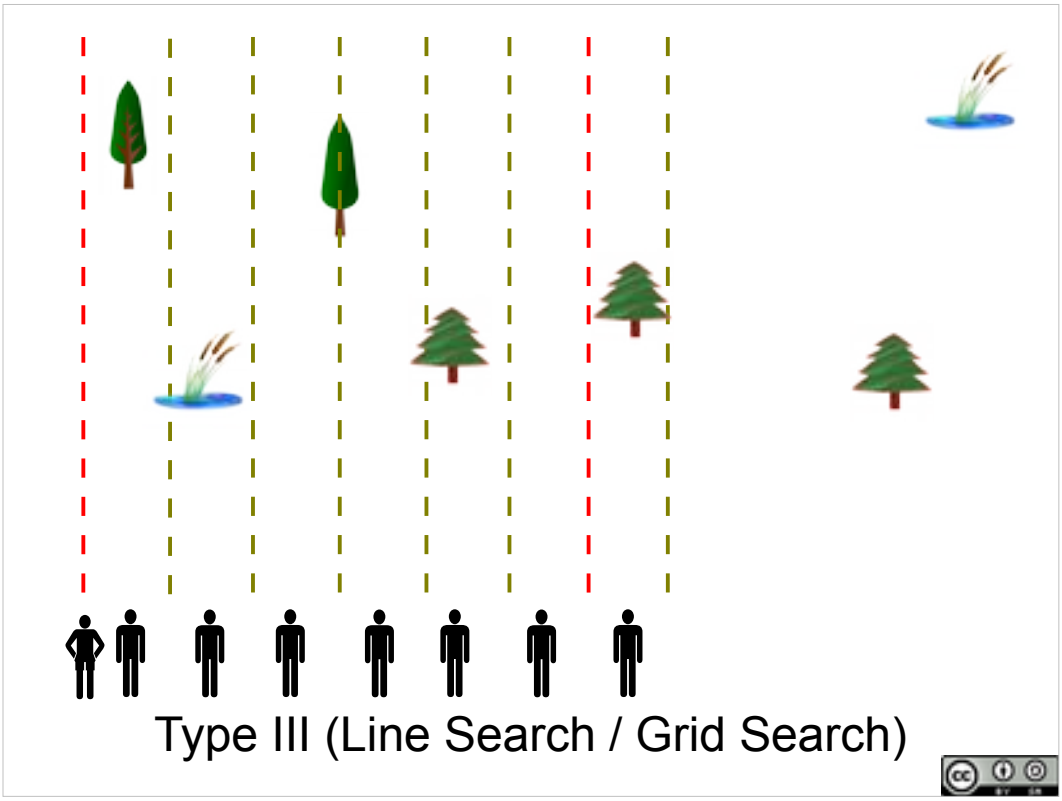
We'll practice this later.

Search Crucials

- Search is an Emergency
- Search is a classic mystery
- Search for clues not just the subject
- Know if the subject leaves the search area
- **Grid search as a last resort**
- Manage by objectives
- Search management is information management

General principle – close grid search as a last resort.

General pattern: Start with Type I searches of travel routes away from the IPP. If the subject category is one that tends not to travel far, also start with Type II searches in the high probability area around the IPP. Then later a progression to more Type II and Type III searches.



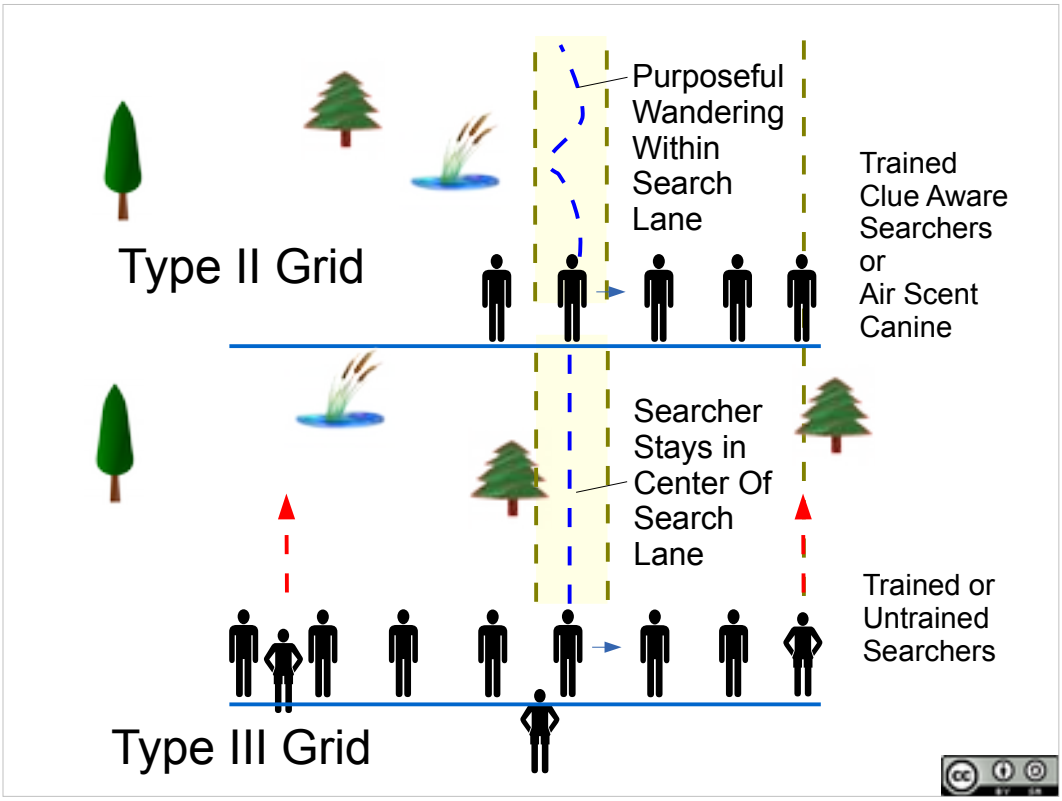
So we move into Type III search.

Type III is a tight grid search, typically with subject finders.

Close spaced grids are inefficient, require large numbers of people, and destroy clues. They use closely spaced subject finders to produce a high probability of detecting a subject in an area.

Maintain span of control and firm control on Type III grids.

Type III searches can use relatively small numbers of untrained searchers mixed with and under the leadership of trained searchers.

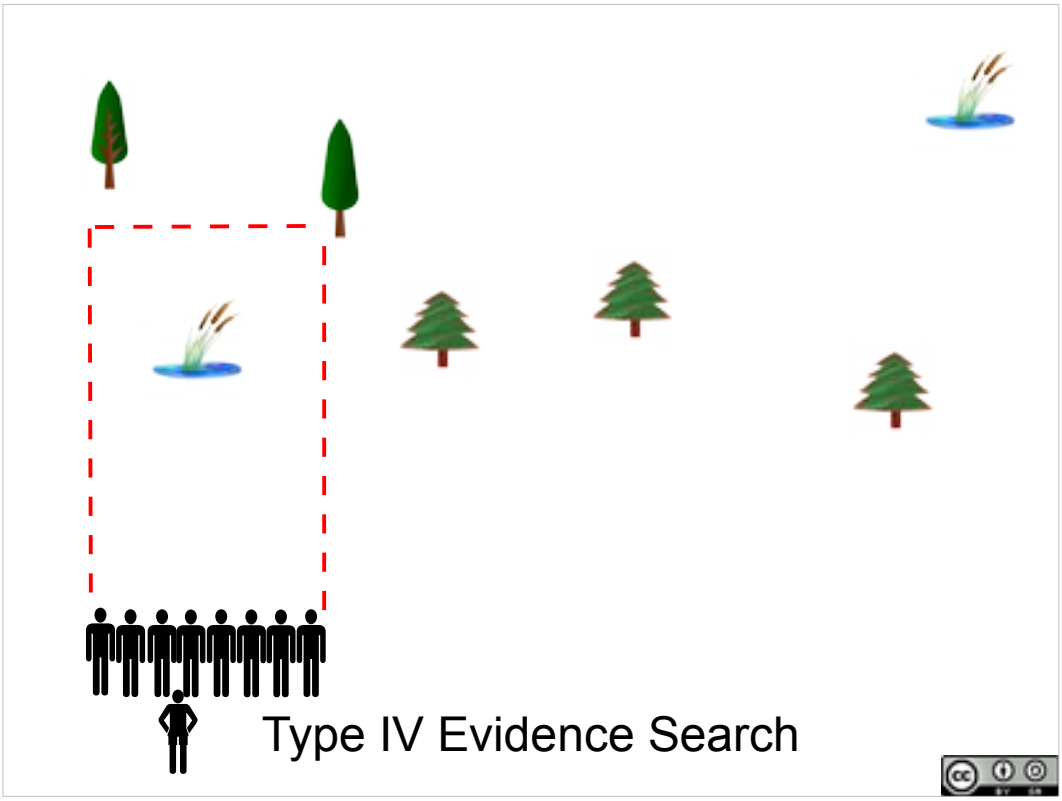


Contrast: Type II grid with purposeful wandering, Type III grid with tight control on unskilled searchers.

Type II searches need trained clue aware searchers.

Type III searches can use a mixture of trained and untrained searchers.

Type III searches need tight control.



Type IV search – evidence search.

Highly destructive – if a clue wasn't found it won't be.

Takes lots of people and lots of time.

Type IV searches tend to be a line of police academy cadets searching a known crime scene for clues.

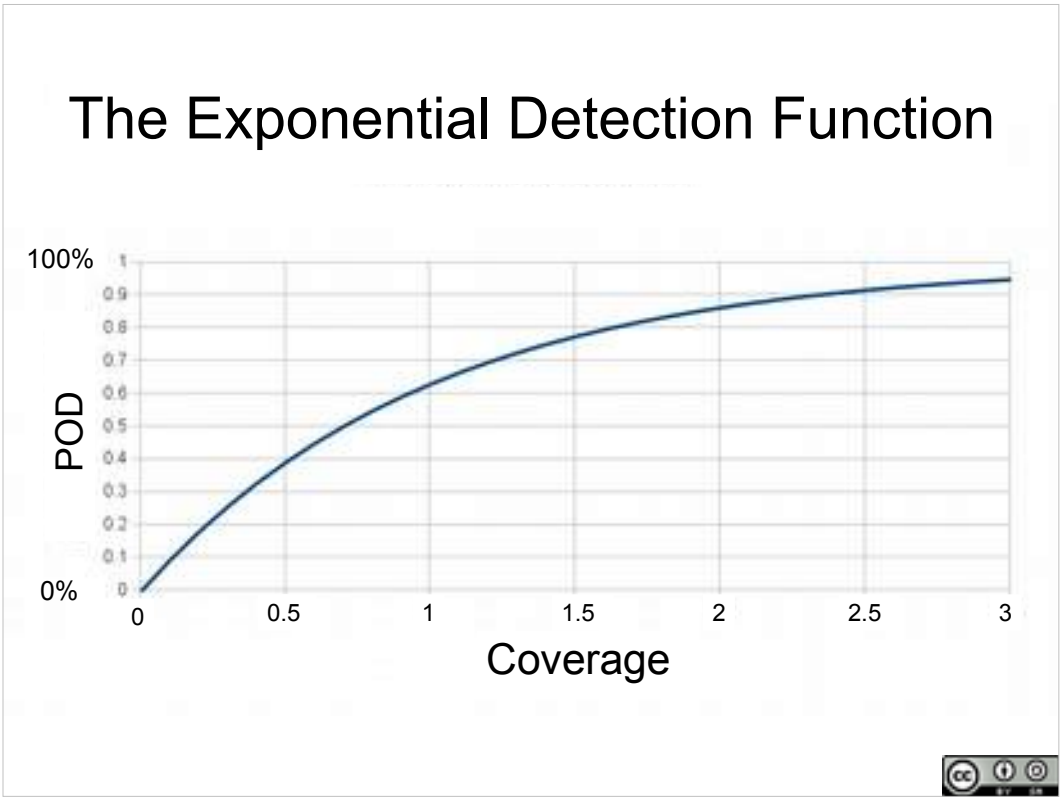
Factors affecting POD for ground search

- Sweep Width
- Area Size/Time
- Tactics
- Terrain
- Vegetation
- Light
- Weather
- Hazards
- Team Composition/Fatigue

How well was the area covered?

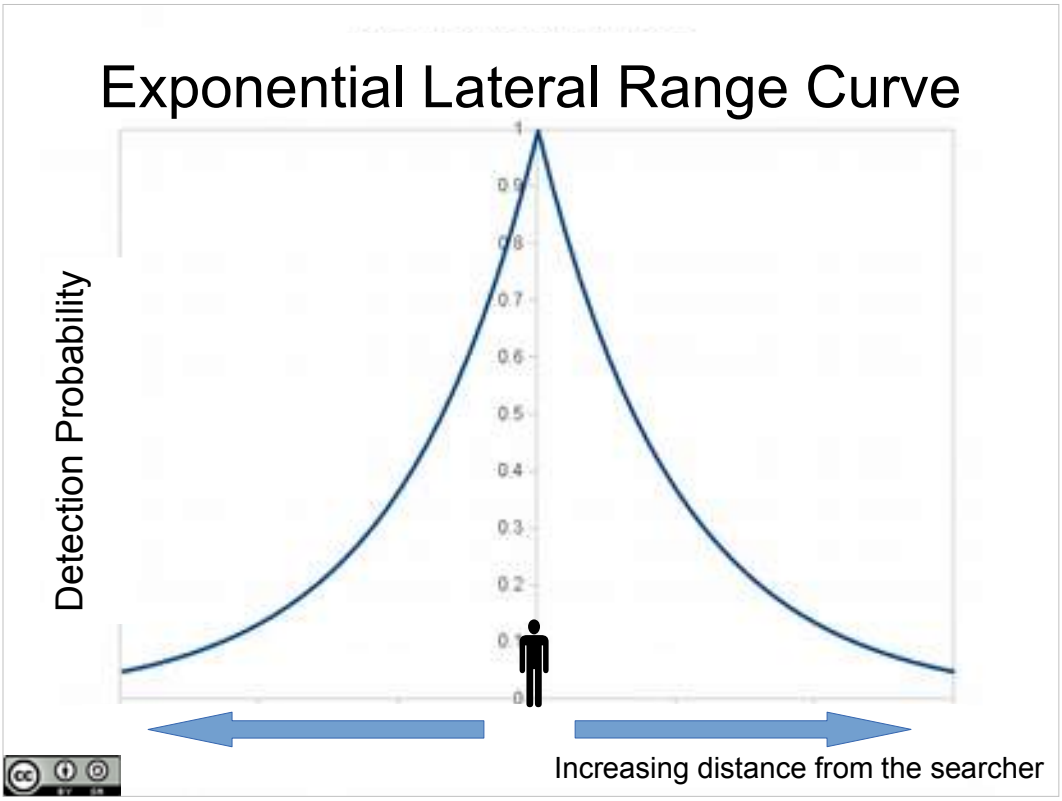
Type II and Type III searches of an area produce some probability of detection for that area.

For ground searchers, the tactics, how far apart searchers are spaced, how fast they are moving (how the size of the area relates to the amount of time spent searching), what the ground cover is like, what the terrain is like, what the light is like, and what the weather is like all affect how well the area was searched, and what the Probability Of Detection was.



Search theory includes an expression of a formal relationship between how well the area was covered and the probability of detection – in this somewhat mysterious graph – the Exponential Detection Function, which relates coverage - a measure of how thoroughly the area has been searched with POD (probability of detection).

Let's see if we can make some sense of this graph.

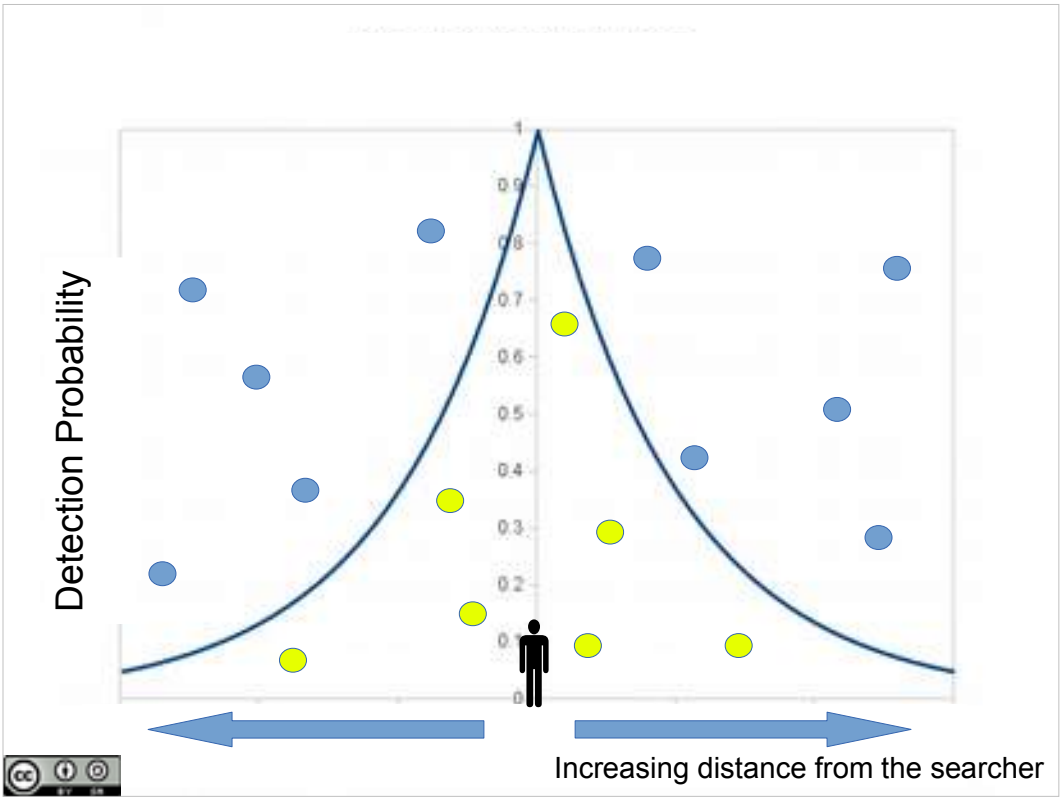


We'll start with this model of detection of subjects by searchers.
This graph holds if the sensors (the searchers) have an ability to detect subjects which decreases exponentially with distance, expressed as an Exponential Lateral Range Curve [not to be confused with the exponential detection function].

Close to the searcher, there is a high probability of the searcher seeing the subject. This probability drops off rapidly the further you get from the searcher.

The searcher is very likely (but not certain) to observe a subject they almost step on.

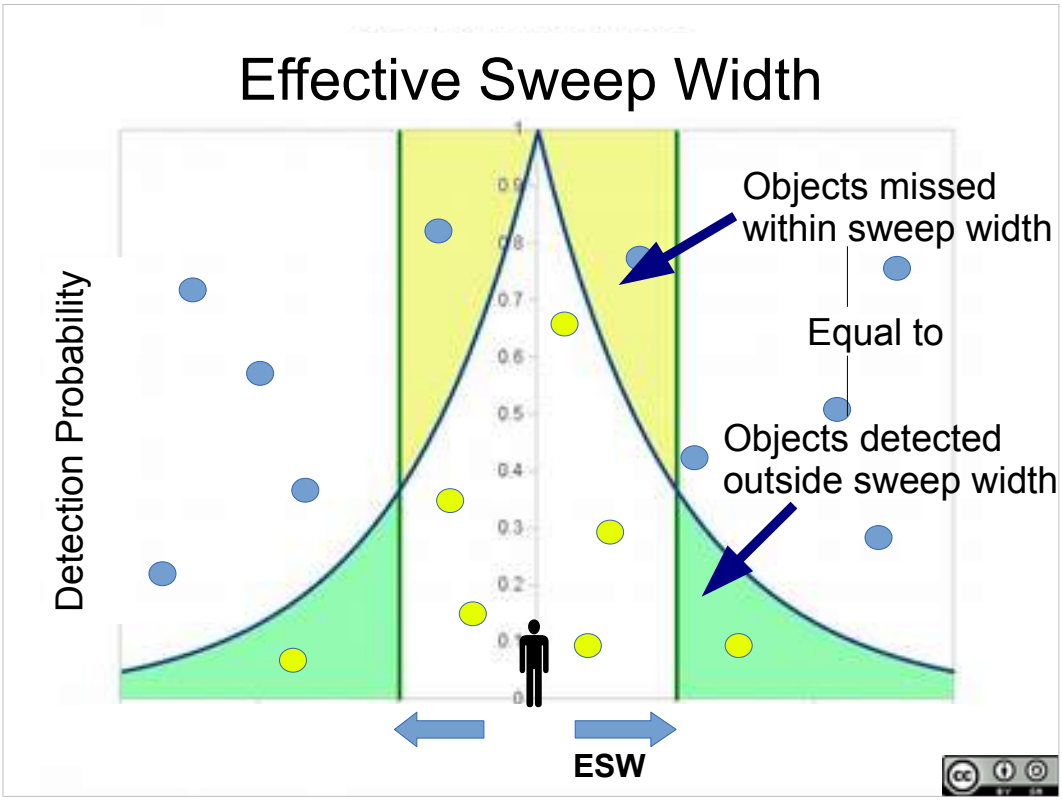
The searcher is much less likely to observe a subject 100 meters away.



Let's consider a searcher walking through an area full of many subject-sized objects.

A searcher will find more of those objects closer to their path, and fewer further away.

We'd like to describe this smoothly decreasing curve with a single width, so...

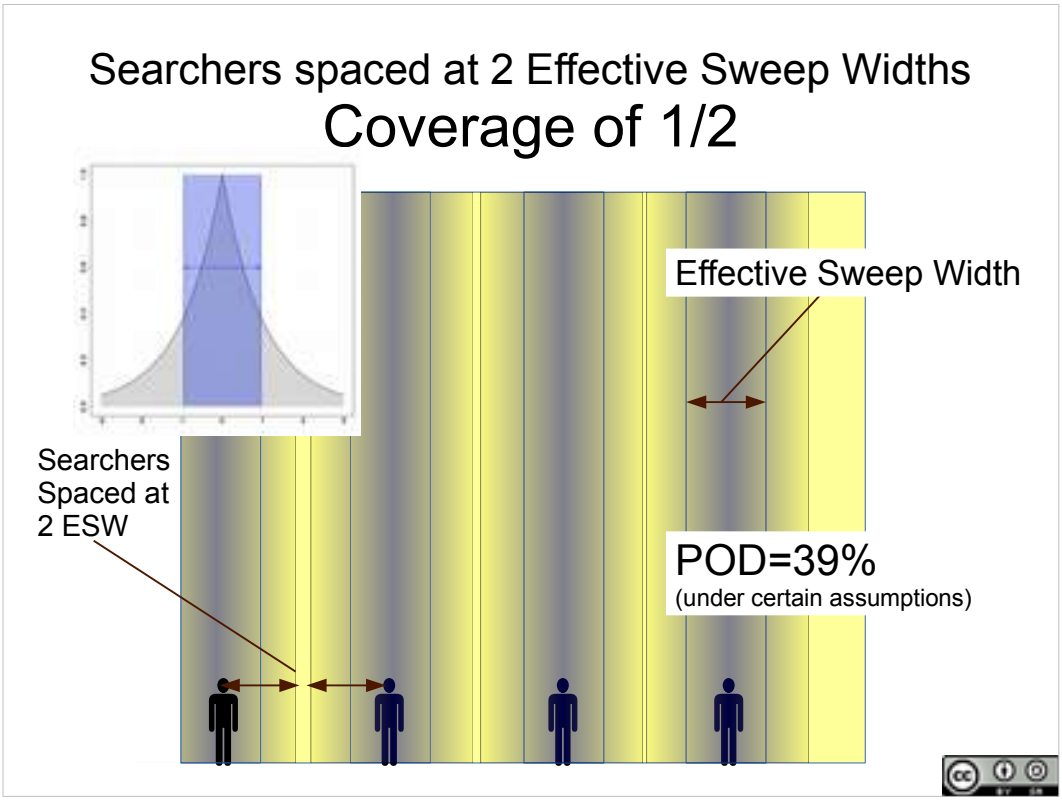


Formal search theory defines something called Effective Sweep Width.

Effective Sweep Width is defined as the distance from the searcher at which as many objects are missed inside that distance as are detected outside that distance.

This also happens to be a rectangle with the same area as the area under the curve.

A close by subject might still be missed, and a far away subject might be detected, but we can model a sweep through a segment by a searcher as a sweep with an effective sweep width.

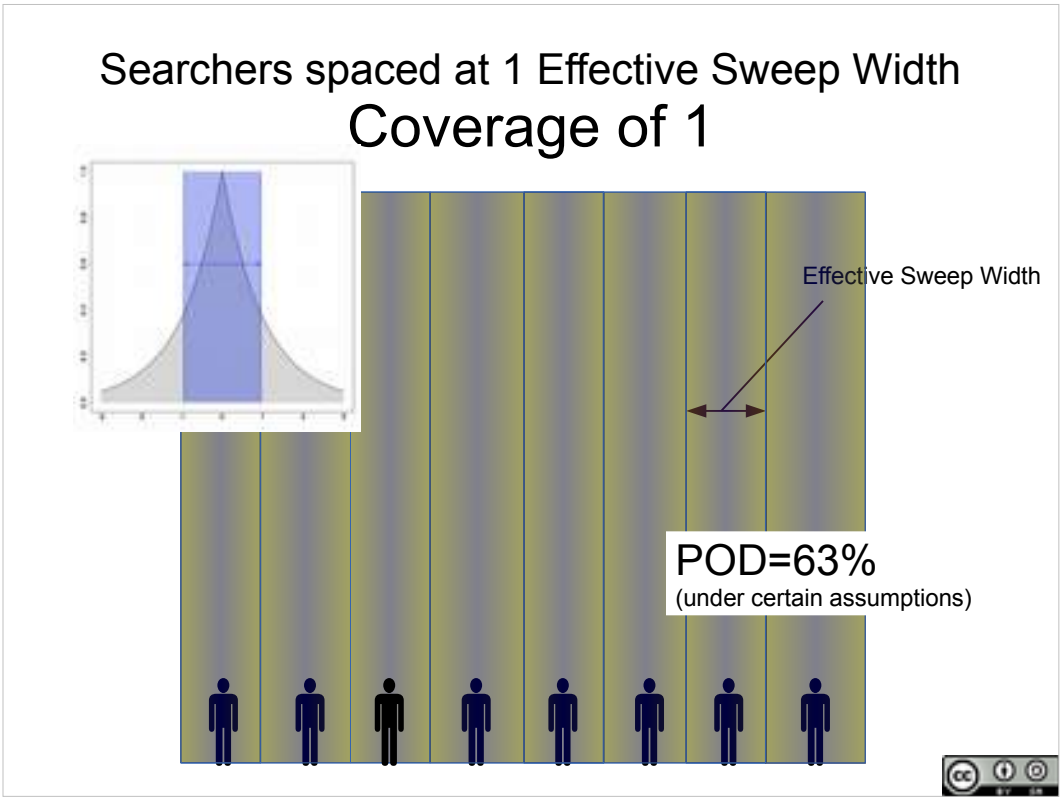


Now let's space a grid line of searchers 2 Effective Sweep Widths apart, so that there is an area of one ESW separating each searcher's ESW.
Half the area is covered within one ESW of a searcher. Half of the area falls more than one ESW away from a searcher.

This is a coverage of one half.

A coverage of 1/2 has a POD of less than 50% as inside each searcher's effective sweep width some subjects will be missed (and outside each searcher's effective sweep width some subjects will be detected).

The POD for a coverage of 1/2 is 39%, depending on certain assumptions about how the area is swept.



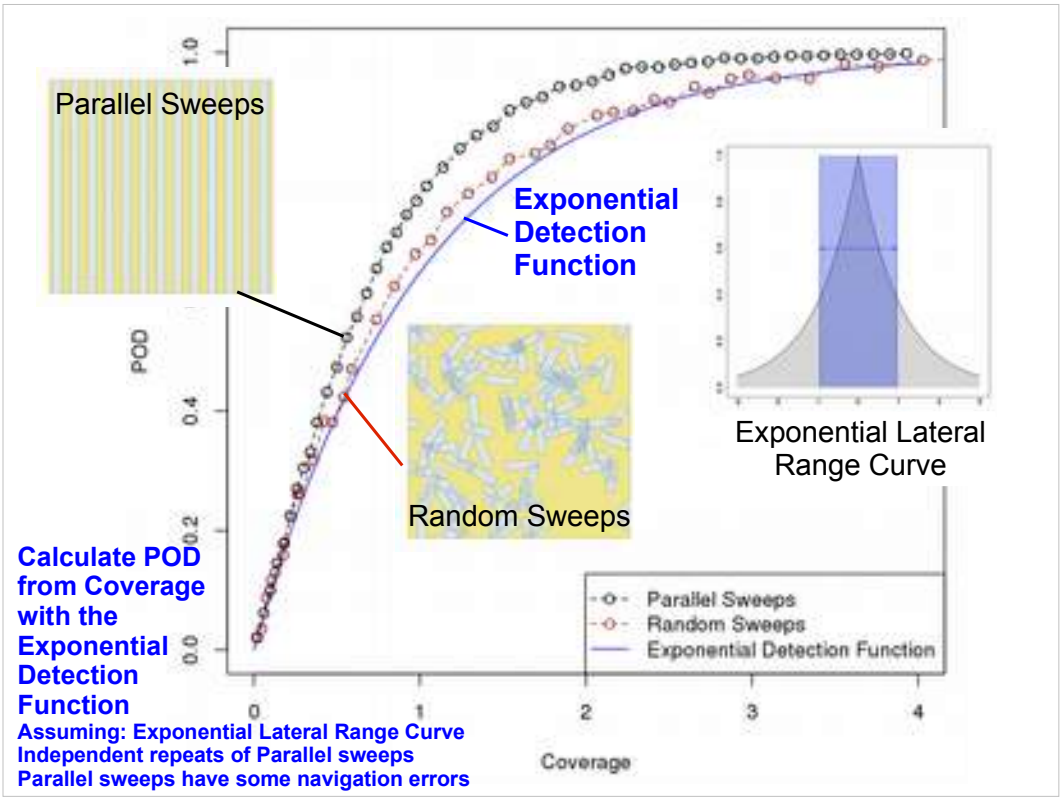
Now let's tighten up the grid line so that searchers are placed at one effective sweep width apart.

All of the area now falls within one effective sweep width of a searcher.

This is a coverage of 1.

Subjects near the searches may still be missed – so even though the entire area falls within one effective sweep width of some searcher, some subjects will be missed and the POD is less than 1.

The POD for a coverage of 1 is 63%, depending on certain assumptions about how the sweeps are placed.



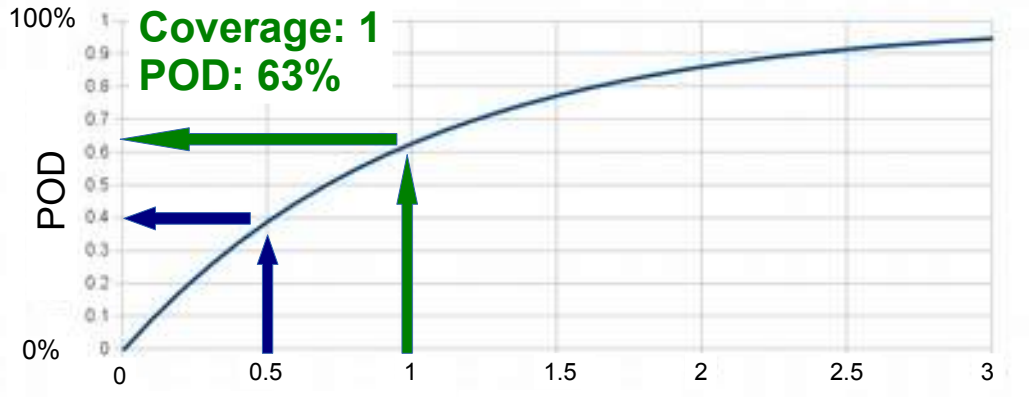
We said “depending on certain assumptions about how the sweeps are placed.”

Given an exponential lateral range curve, if the parallel sweeps are perfectly neat and clean and parallel, then the detection function (Coverage-POD relationship) lies above the Exponential Detection Function we showed earlier.

But, if we make lots of short randomly placed sweeps, then the Coverage-POD relationship (the red circles and line here (from a simulation)) approximates the Exponential Detection Function.

We don’t search in short randomly placed sweeps, but adding small navigation errors to parallel sweeps, and sweeping the same area more than once with independent sensors (who don’t line up exactly on the previous sweeps), shifts the Coverage-POD relationship to close to the Exponential Detection Function.

The Exponential Detection Function

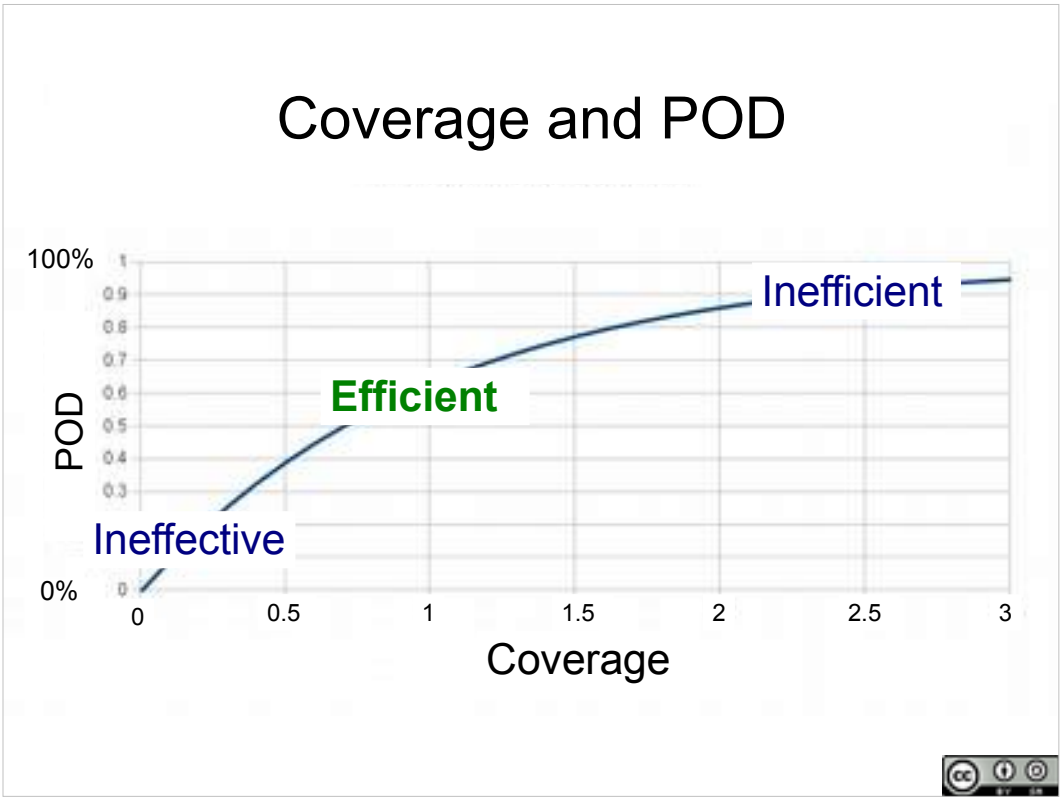


We thus think of the Exponential Detection Function as a conservative way of estimating the Coverage-POD relationship accounting for navigation errors and independent repeat searches (lots more on that in a search management course).

The exponential detection function lets us answer the question: given some coverage, what's the POD.

The important thing to note here is: that there are big gains in POD in going from a coverage of 1/4 (POD=22%) to 1/2 (POD=39%), gains in going from a coverage of 1/2 to 1 (POD=63%), less going to a coverage of 2 (POD=86%), and very small gains with each increase in effort over a coverage of 2.

Doubling the effort in going from a coverage of 1/4 to 1/2 nearly doubles the POD, doubling the effort again to a coverage of 1 increases the POD by about 50%, doubling the effort again increases the POD by only about 30%.

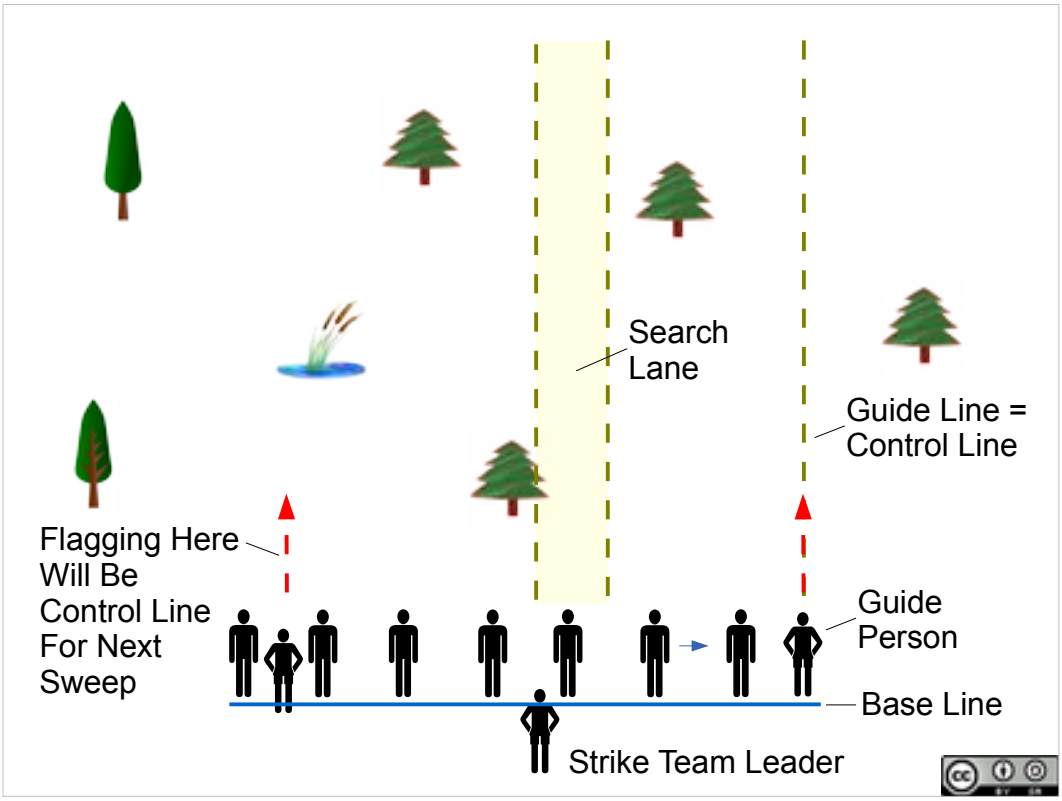


Low coverages are ineffective – they get low probabilities of detection.

High coverages are inefficent.

The resources used to go from a coverage of one to a coverage of two in one segment would be better used to search a second segment at a coverage of 1 (if we search two segments we probably get a higher Probability Of Success than if we only search one).

A coverage of about 1, with a POD of about 63% is efficient, and what search planners aim to target.

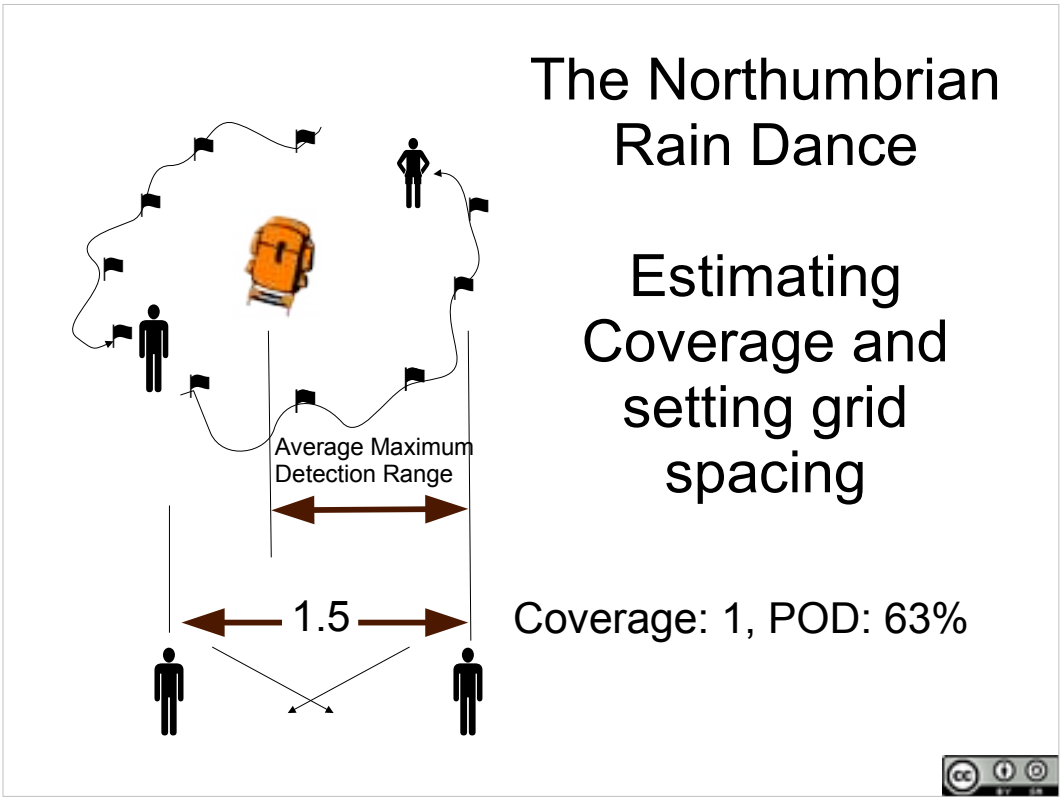


Let's come back to the Type II or Type III grid.

How wide do we make the search lanes (how far apart do we place searchers) to try to obtain a coverage of 1?

There isn't a formula for ground search (too many variables: terrain, weather, vegetation, light).

There is practical, rule of thumb way of finding out how far apart to place searchers.



Called the Northumbrian Rain Dance.

Place an object the size of a subject (like a backpack) on the ground, in terrain and vegetation typical of the search area.

Have several people walk away from and towards the object, marking the points at which the object just ceases to be detectable

Add up these maximum detection ranges, and take an average (the Average Maximum Detection Range).

Spacing searchers at one and one half this Average Maximum Detection Range can be used “with some trepidation” as a practical way of estimating spacing for a coverage of One in a ground grid search.

Functional Roles on an assignment

- Leader
- Navigation
- Communication
- Ground Searcher
- Medical

There are lots of responsibilities in a resource that is searching. Divide those responsibilities up.

A resource being deployed on some search assignment (Ground or Canine, Type I, II, III or IV) will need:

A leader (a field team leader, or the canine handler).

A navigator

Ground searchers (to look for clues and the subject).

Someone to handle communications.

Someone to handle medical situtations.
(and Law Enforcement functions on locating crime scenes).

Good composition of an air scent canine resource, the canine and handler, and three additional people to provide navigation, communications, and medical support, everyone able to observe for clues.

Handler's focus is on the dog and it's behaviors, everyone else can also observe the dog and support the handler.

Four people is a good minimum. If necessary (e.g. someone gets hurt and the route in to them needs to get flagged), the task can split in two groups without anyone needing to be left alone.

Individual Responsibilities

- Own Gear
  - Navigation, Flagging, Lights, PPE, Survival
- Dressed appropriately for terrain and weather
- Physically and mentally prepared

There are also responsibilities for each individual searcher.

You need to be prepared to search.