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Use of GPS-tracking Data to Locate Bird Nests and Estimate Reproductive Outcome

Simona Picardi

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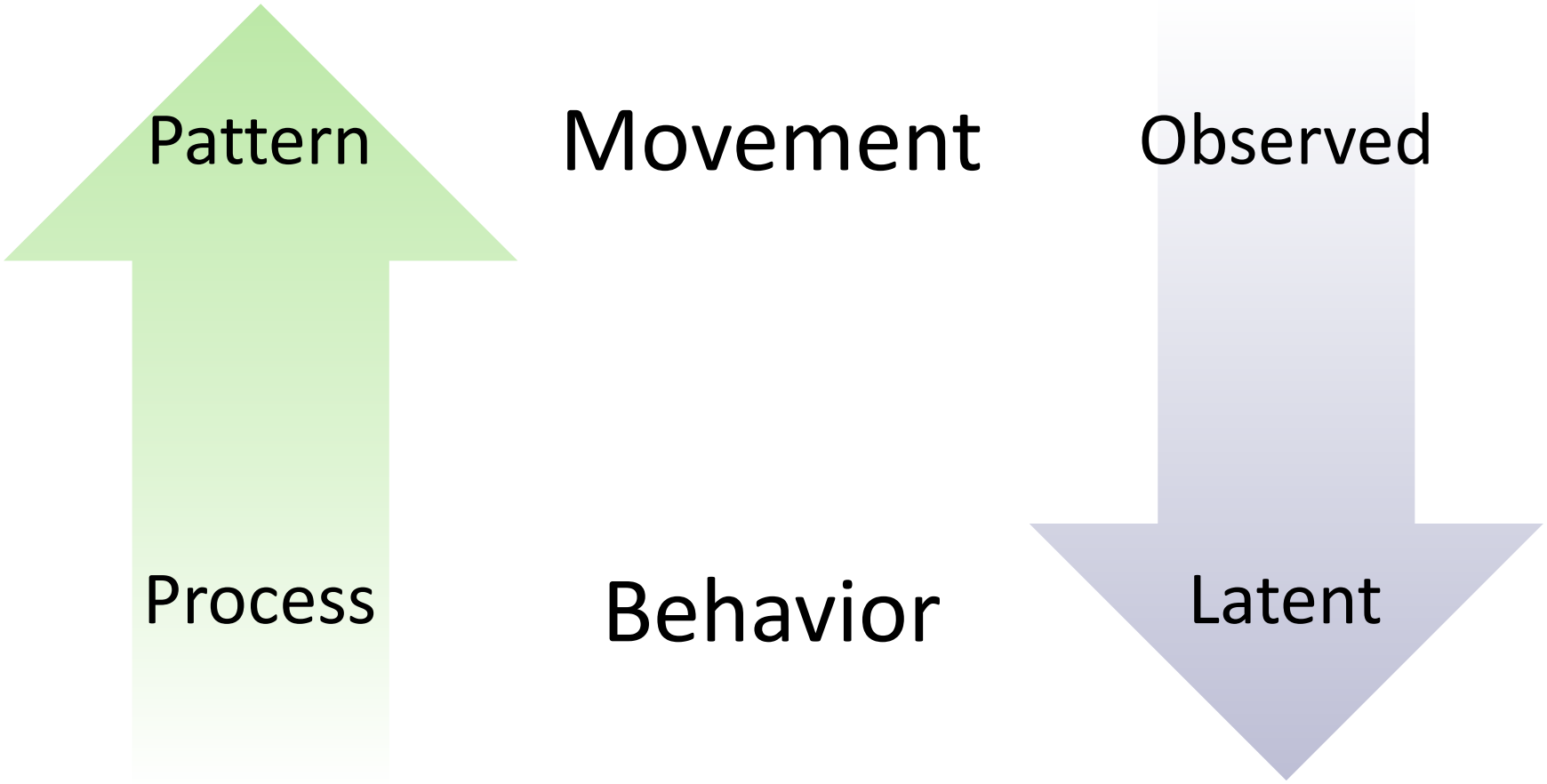
Sistema Nazionale per la Protezione dell'Ambiente

UF UNIVERSITY of FLORIDA

USGS science for a changing world

UNIVERSITÀ DEGLI STUDI DI MILANO


Pattern
Movement
Observed
Process
Behavior
Latent

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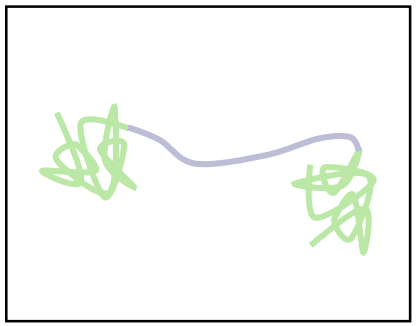

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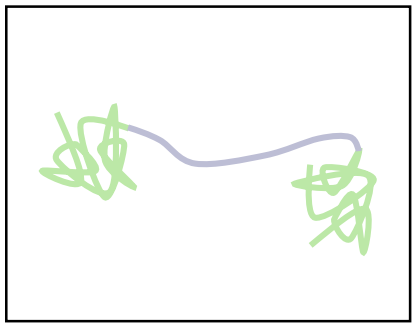

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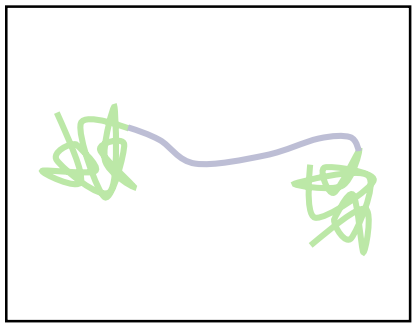

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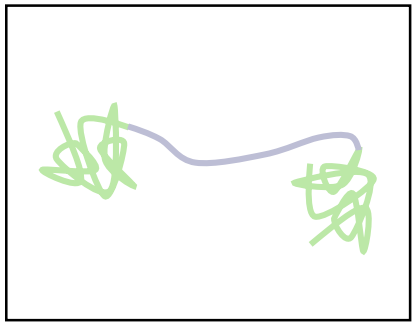

Recursive Movement Patterns

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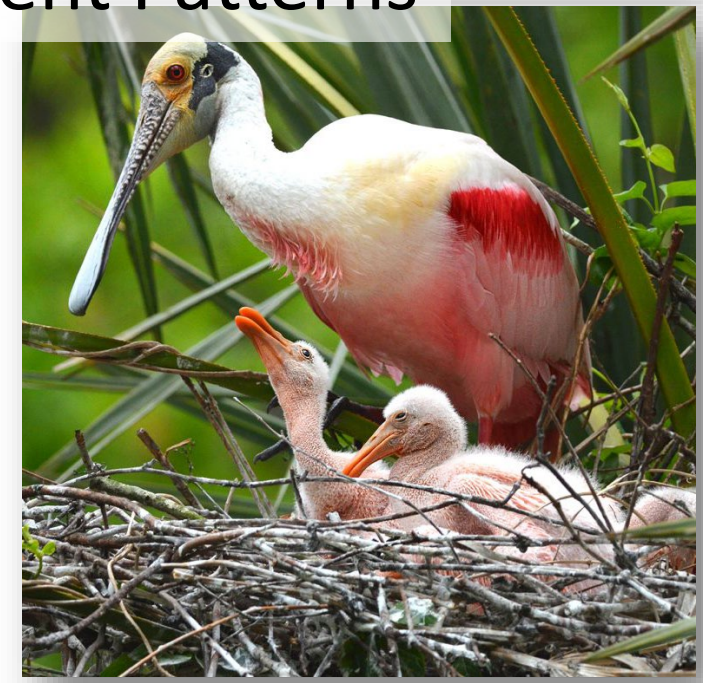
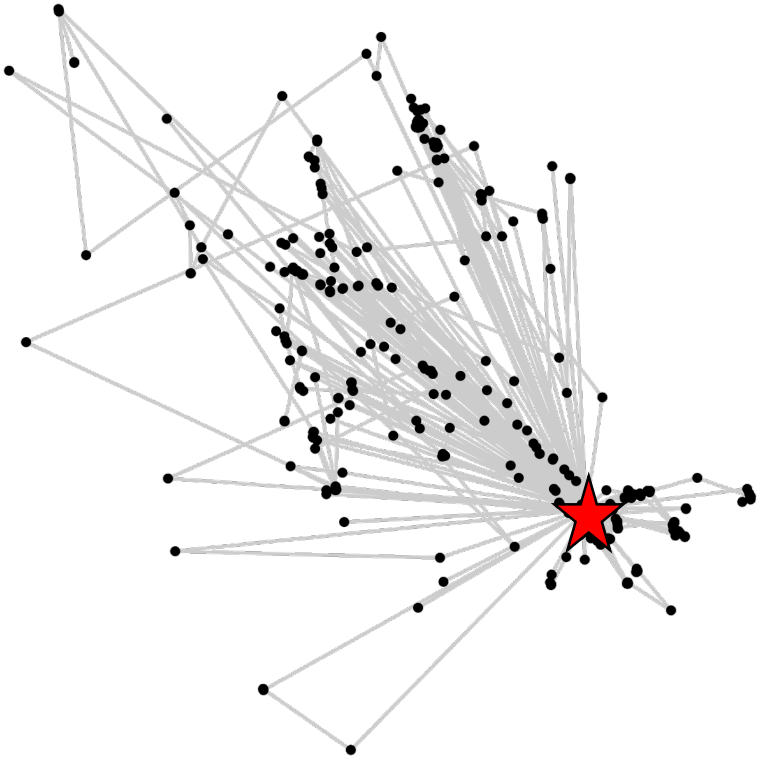


Central Place Foraging



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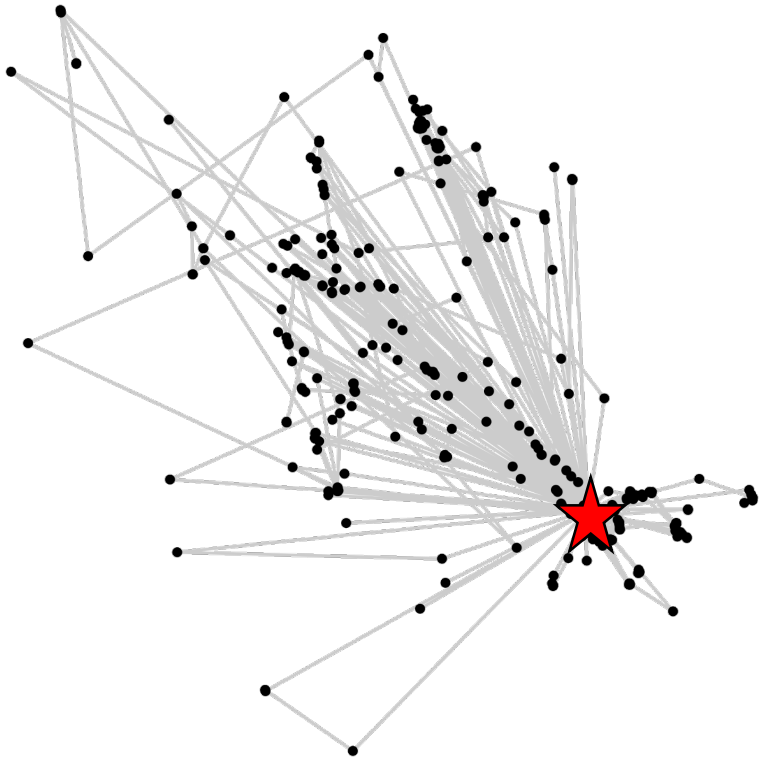

Revisitation Patterns:

- Consecutive days
- Percent days visited
- Percent attendance on top day

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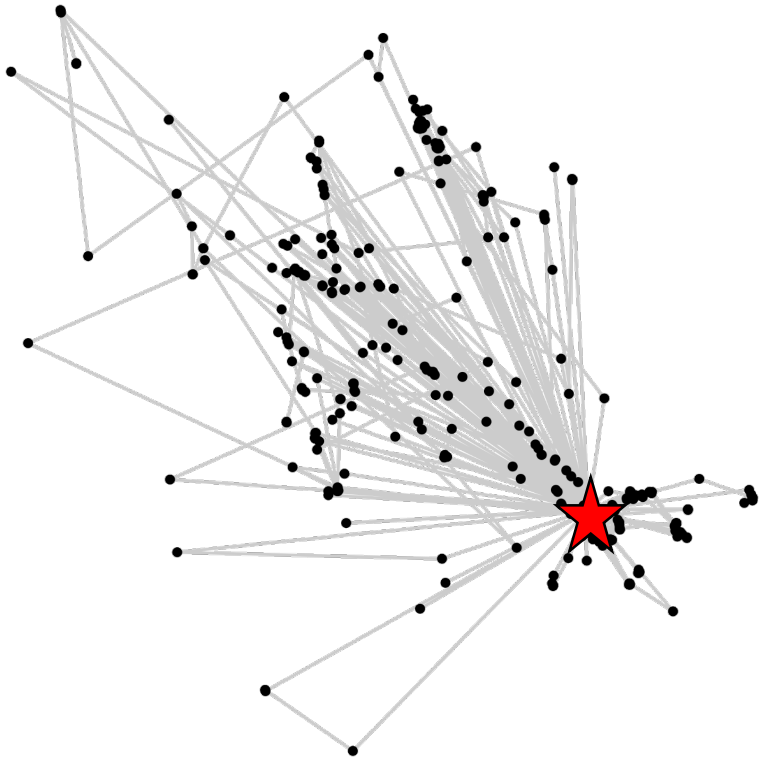


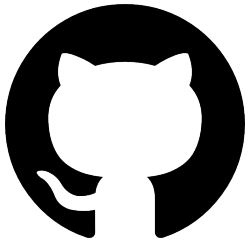
Revisitation Patterns:

- Consecutive days
- Percent days visited
- Percent attendance on top day

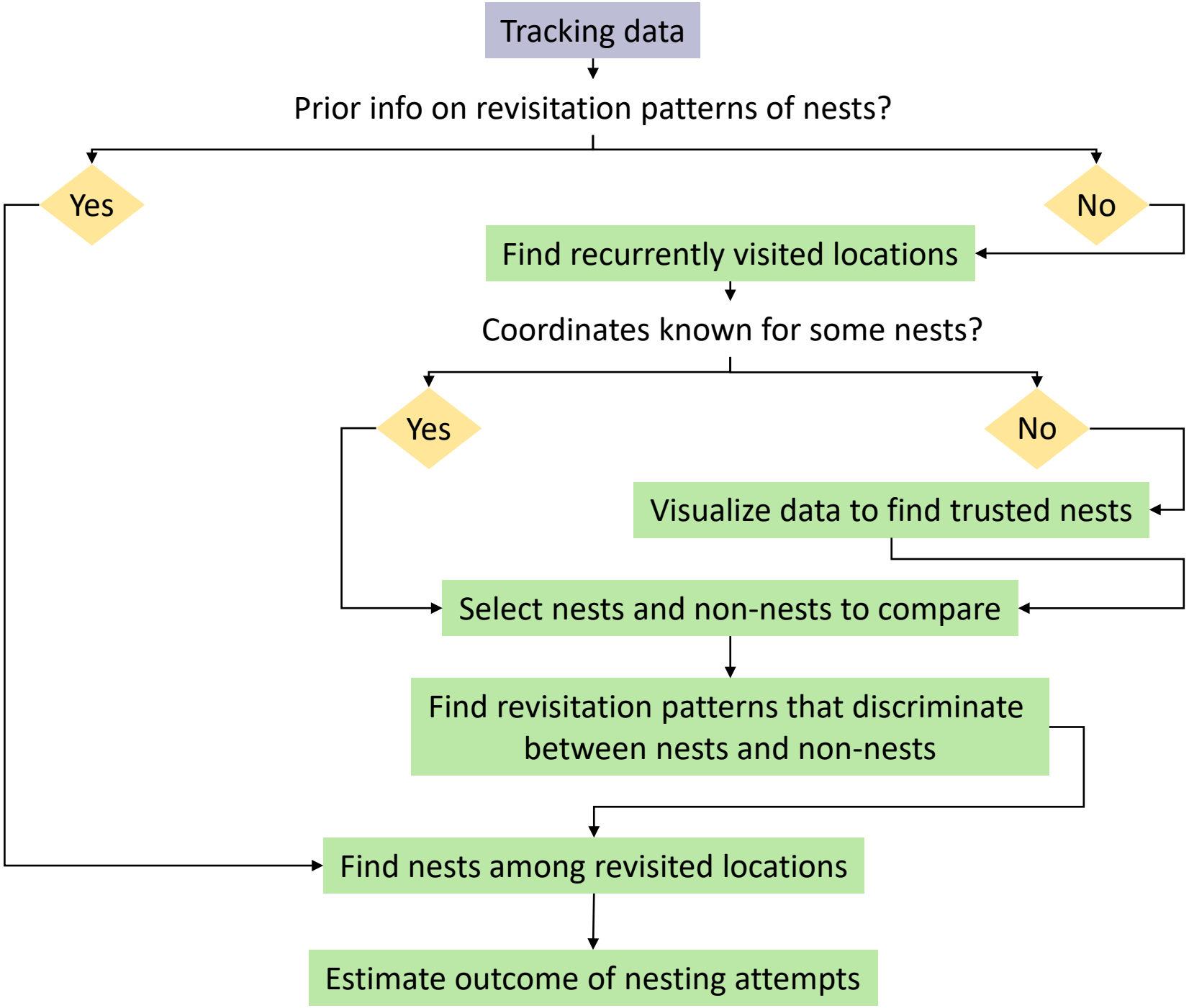
Assumption: revisitation patterns differ between nests and non-nests

Workflow

package ‘nestR’



https://github.com/picardis/nestR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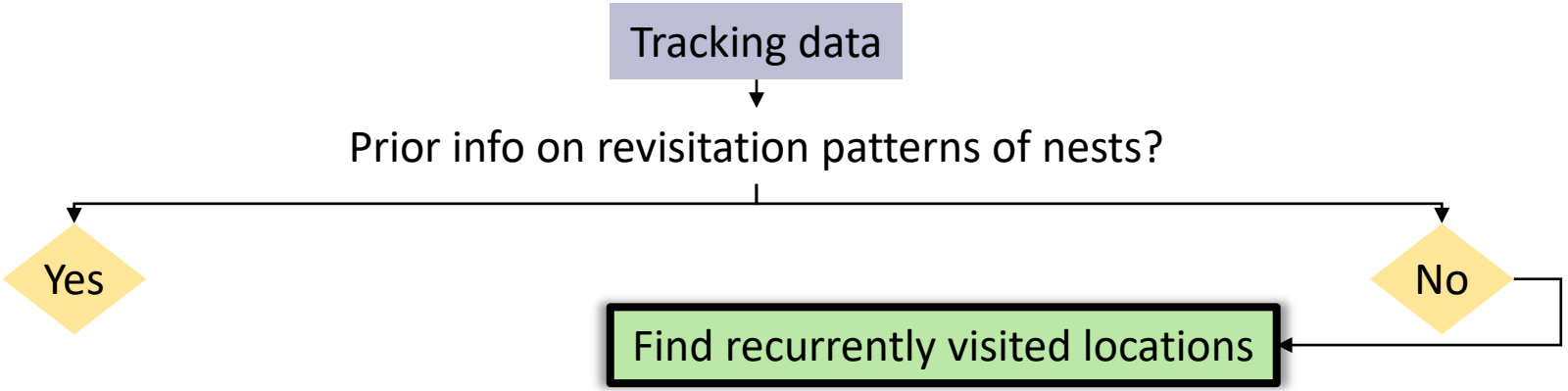
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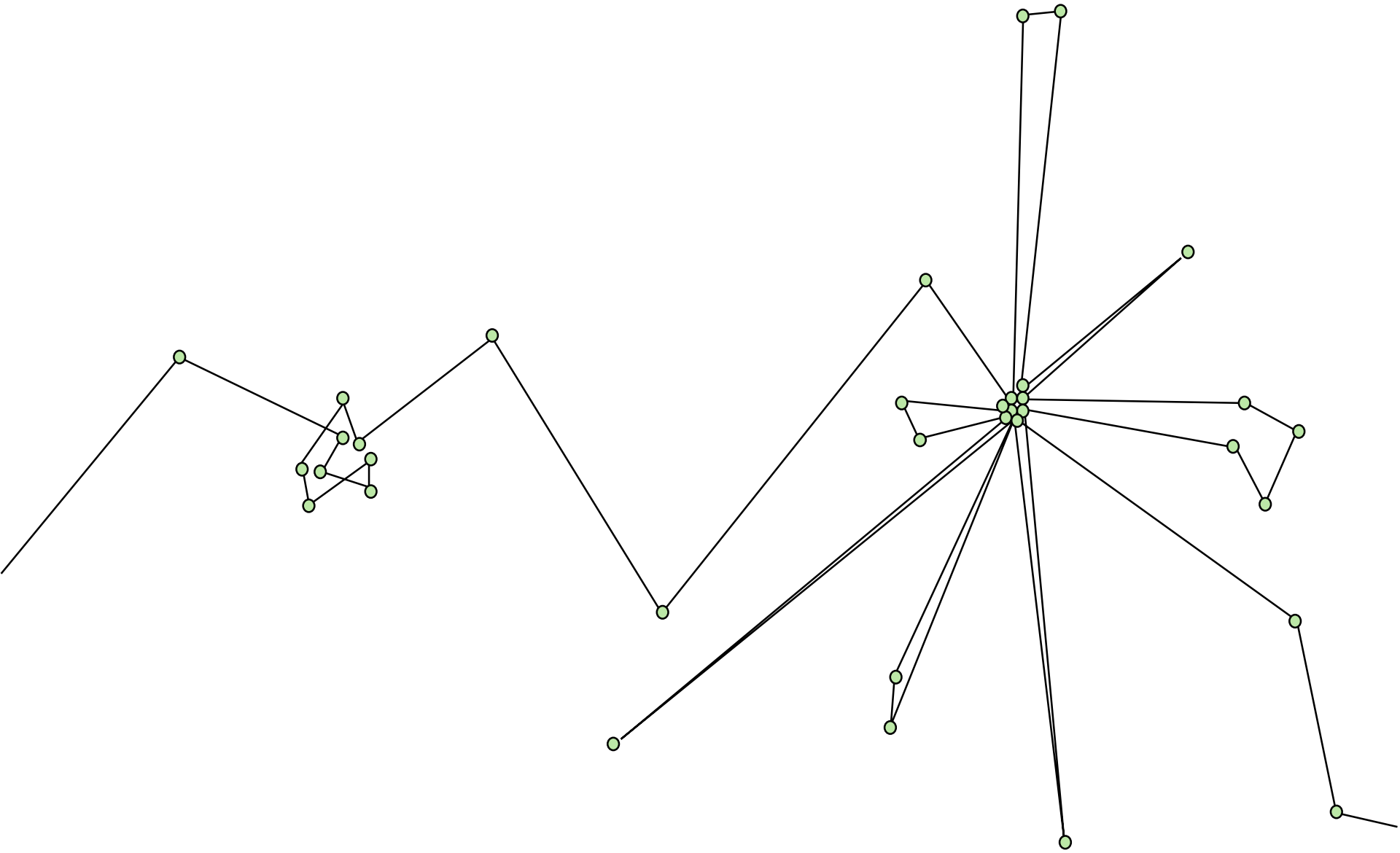

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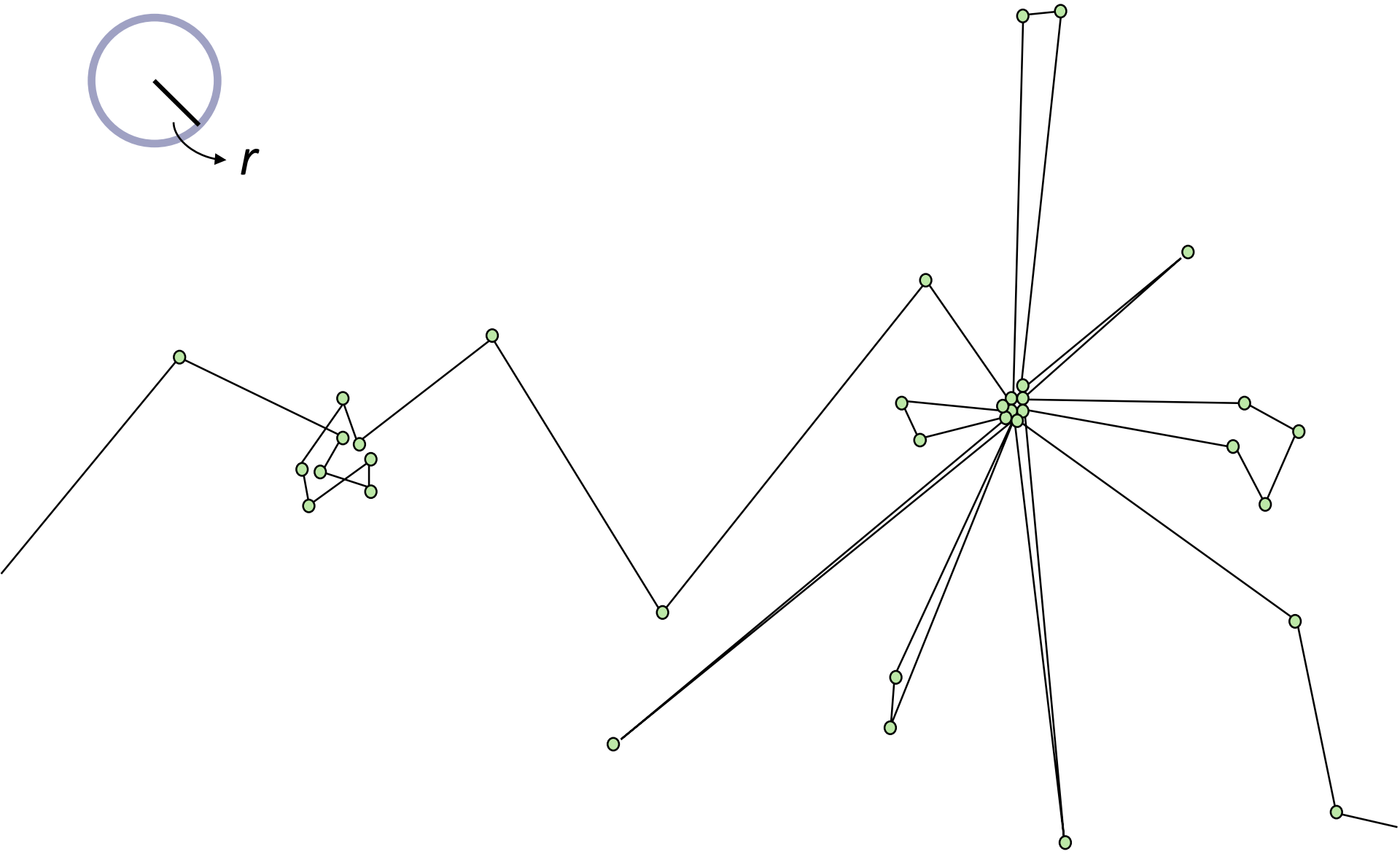

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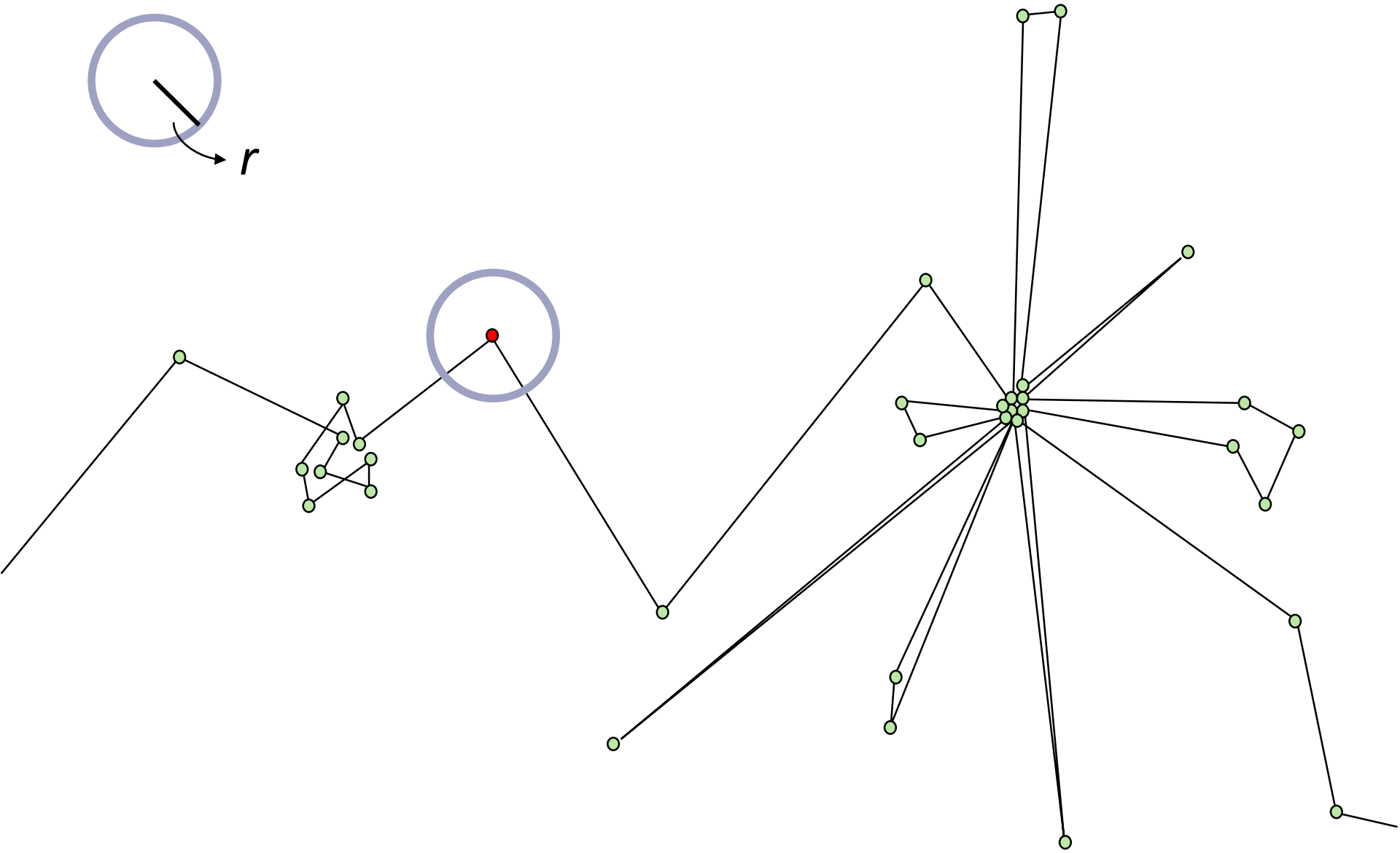

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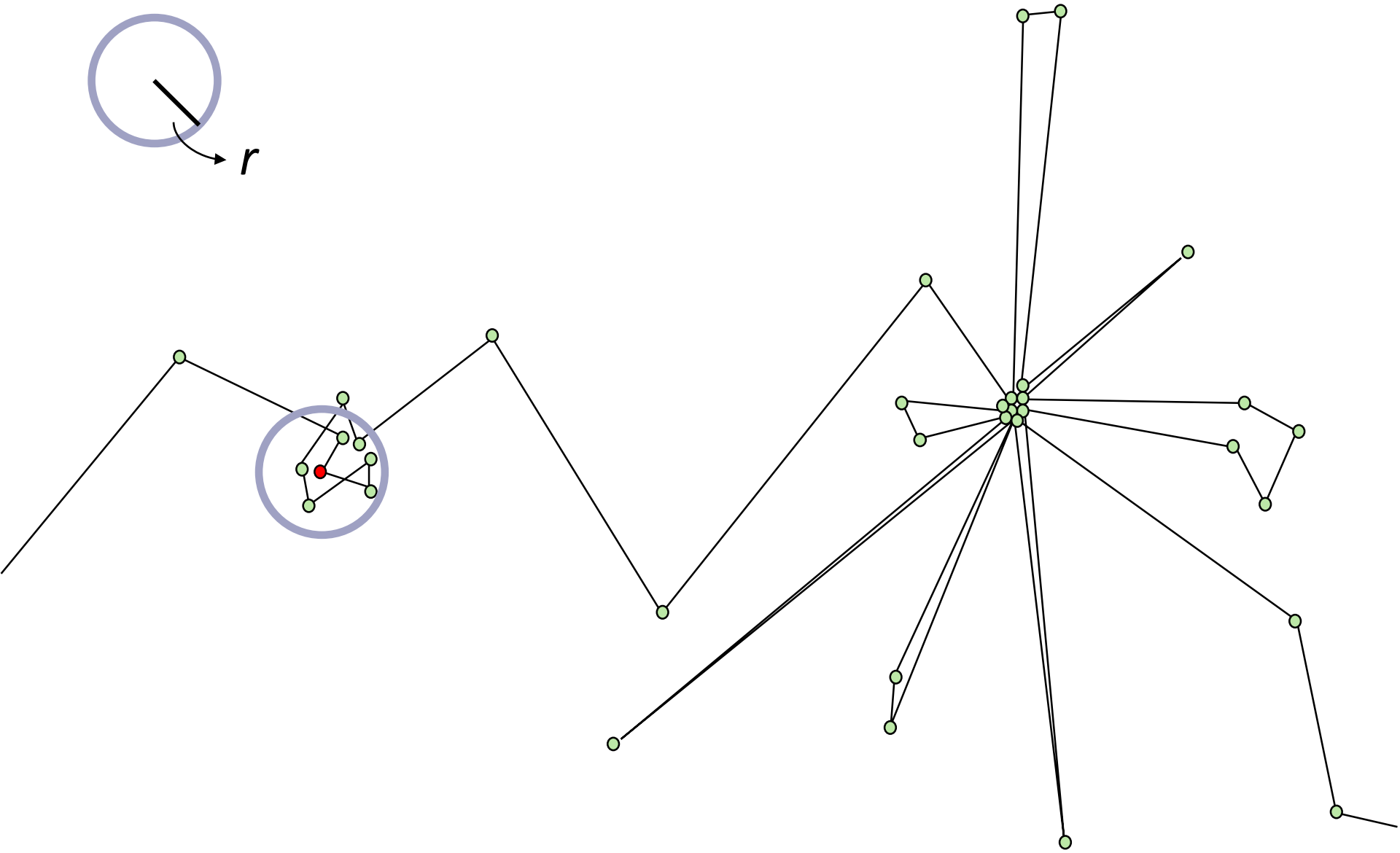

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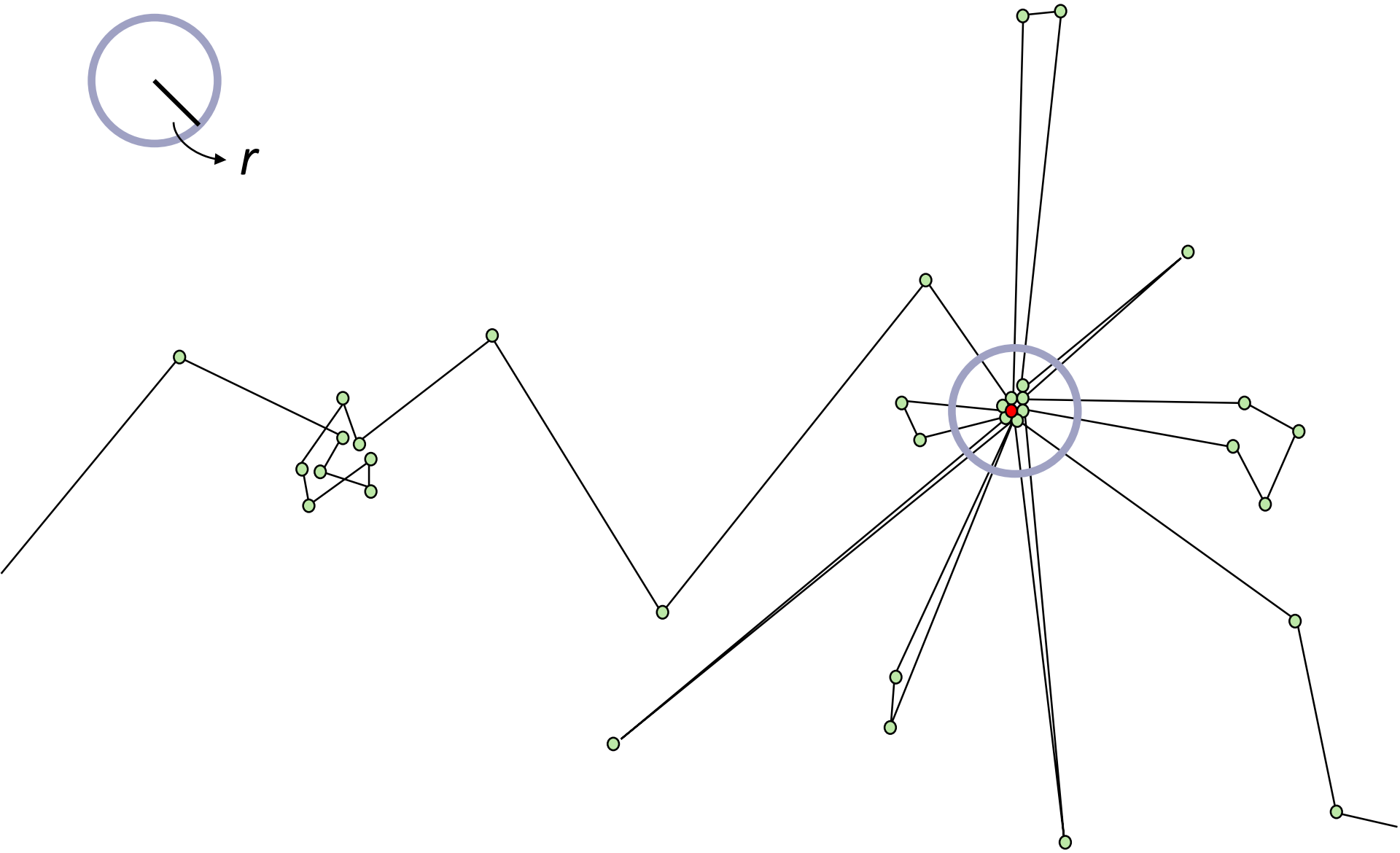

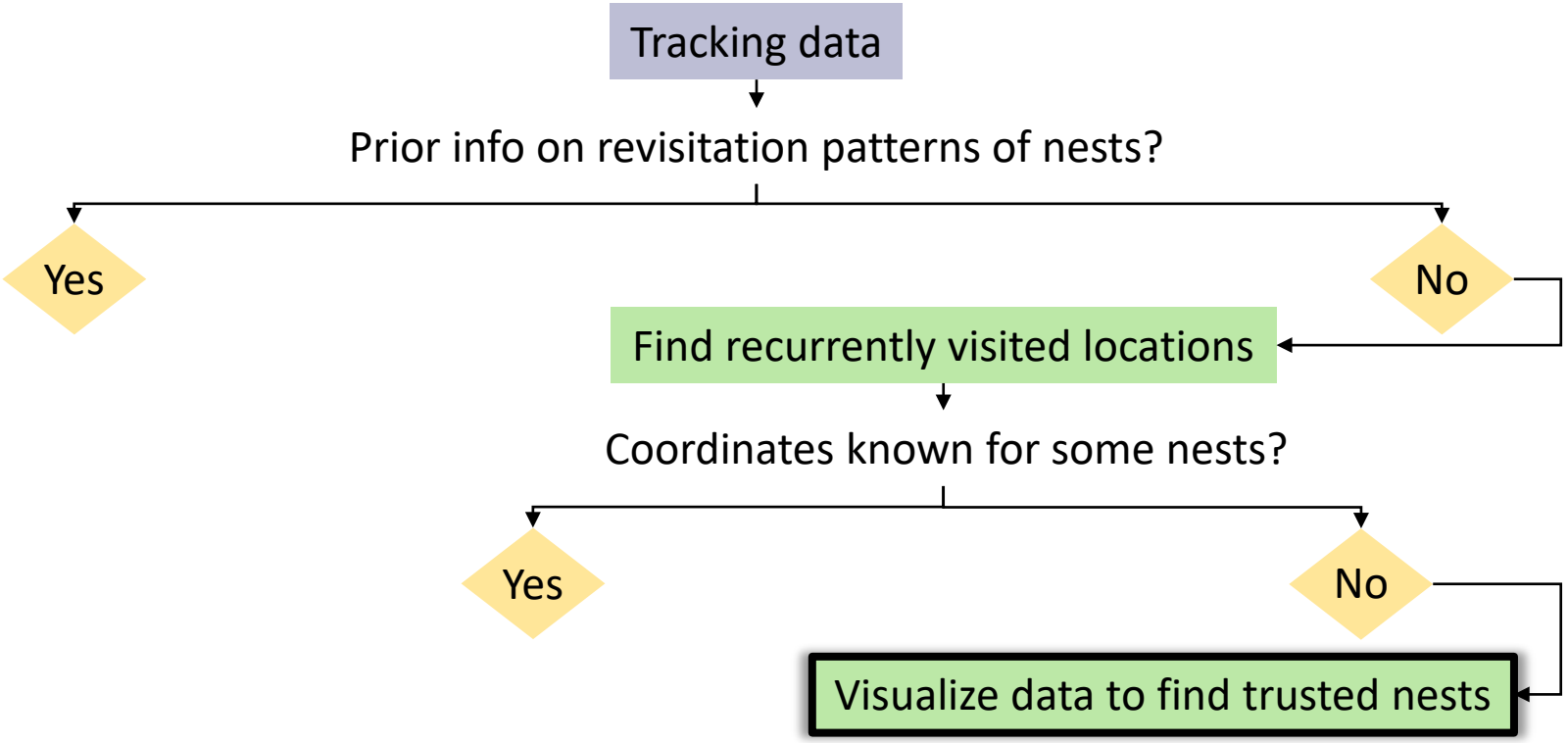
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nestR

Input parameters

Species-specific parameters

Start of nesting season

11-01

End of nesting season

08-31

Duration of complete nesting cycle (days)

110

Data-related parameters

Buffer (m)

40

Minimum points within a buffer

2

Minimum daily fixes

5

Filtering parameters

Minimum consecutive days

2

Minimum % attendance on top day

1

Minimum % days visited

1

Discard temporally overlapping attempts

Burst

1134370-2013

Find nests

Show 10 entries

burst	loc_id	long	lat	first_date	last_date	attempt_start	attempt_end	tot_vis	days_vis	consec_days	perc_days_vis	perc_top_vis
1134370-2013	2170	-80.85100	25.46283	2013-02-24	2013-05-02	2013-02-24	2013-05-02	589	61	37	89.71	100.00
1134370-2013	3270	-79.39017	33.14267	2013-05-12	2013-06-03	2013-05-12	2013-06-03	219	22	20	95.65	100.00
1134370-2013	1023	-80.57167	25.48183	2012-11-27	2012-12-20	2012-12-07	2012-12-20	97	15	14	62.50	87.50
1134370-2013	2364	-80.84683	25.46033	2013-02-02	2013-04-18	2013-03-08	2013-04-18	87	37	17	48.68	35.71
1134370-2013	1391	-80.54367	25.24817	2012-12-23	2013-01-17	2012-12-23	2013-01-17	60	17	4	65.38	83.33
1134370-2013	1317	-80.54383	25.24900	2012-12-23	2013-01-19	2012-12-23	2013-01-19	54	16	8	57.14	80.00
1134370-2013	857	-80.56700	25.51517	2012-11-28	2013-01-25	2012-11-28	2013-01-25	49	8	3	13.56	71.43
1134370-2013	1048	-80.57017	25.48033	2012-11-26	2013-01-25	2012-12-10	2013-01-25	48	11	6	18.03	53.33
1134370-2013	1873	-80.85133	25.46200	2013-02-05	2013-02-24	2013-02-17	2013-02-24	42	7	5	35.00	87.50
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burst	loc_id	long	lat	first_date	last_date	attempt_start	attempt_end	tot_vis	days_vis	consec_days	perc_days_vis	perc_top_vis

Showing 1 to 10 of 38 entries

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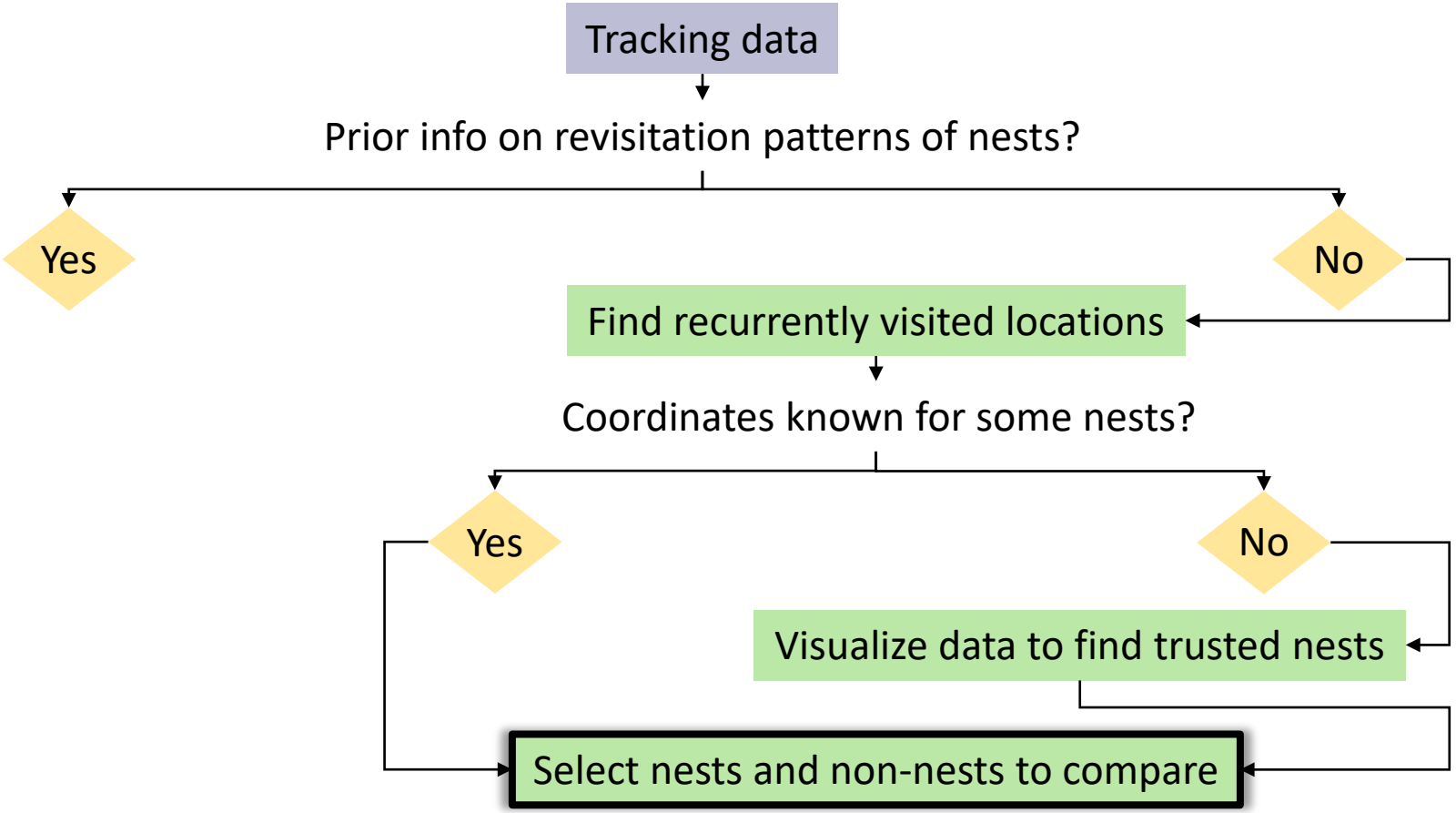
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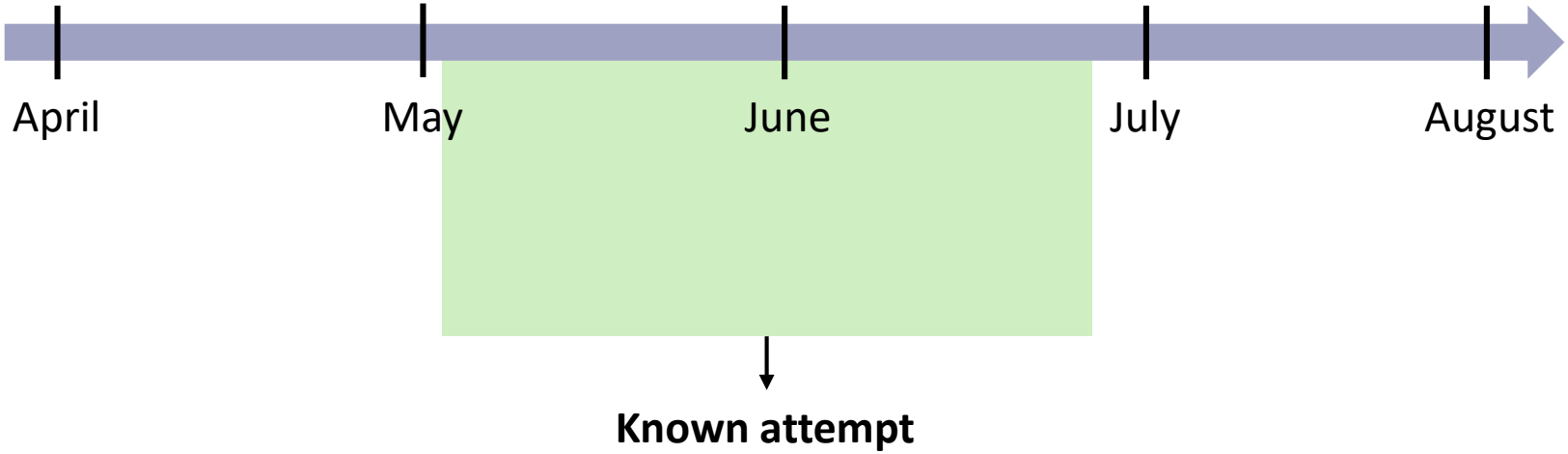

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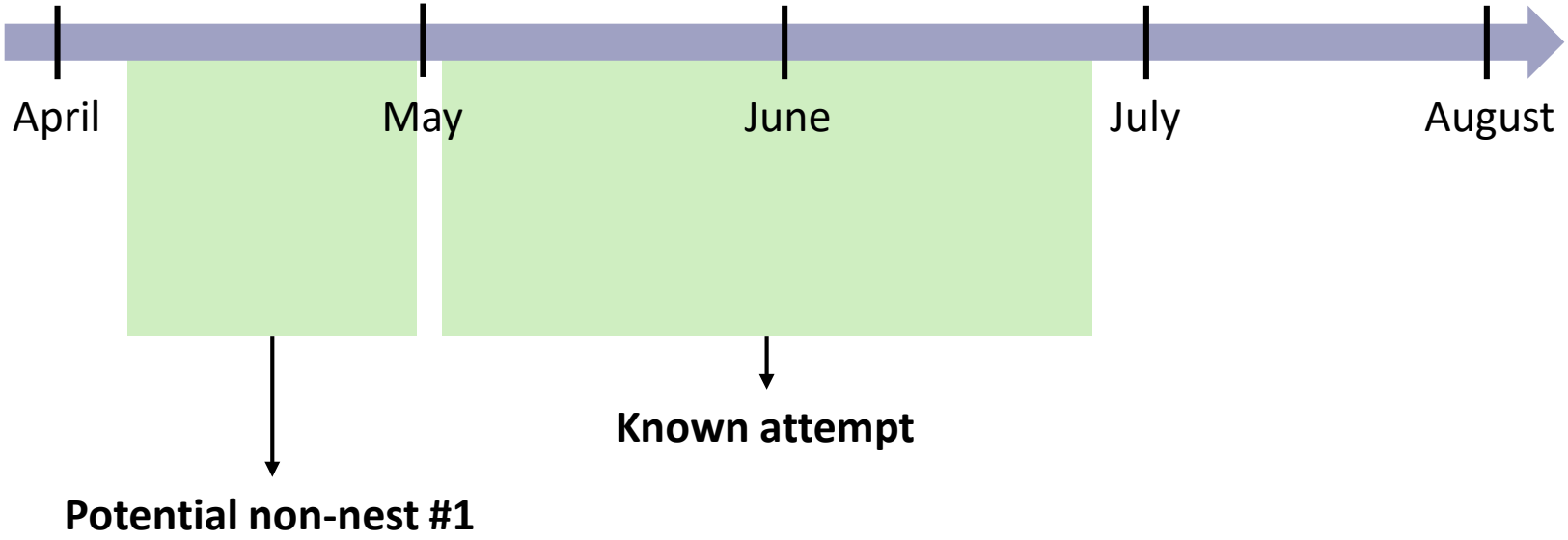

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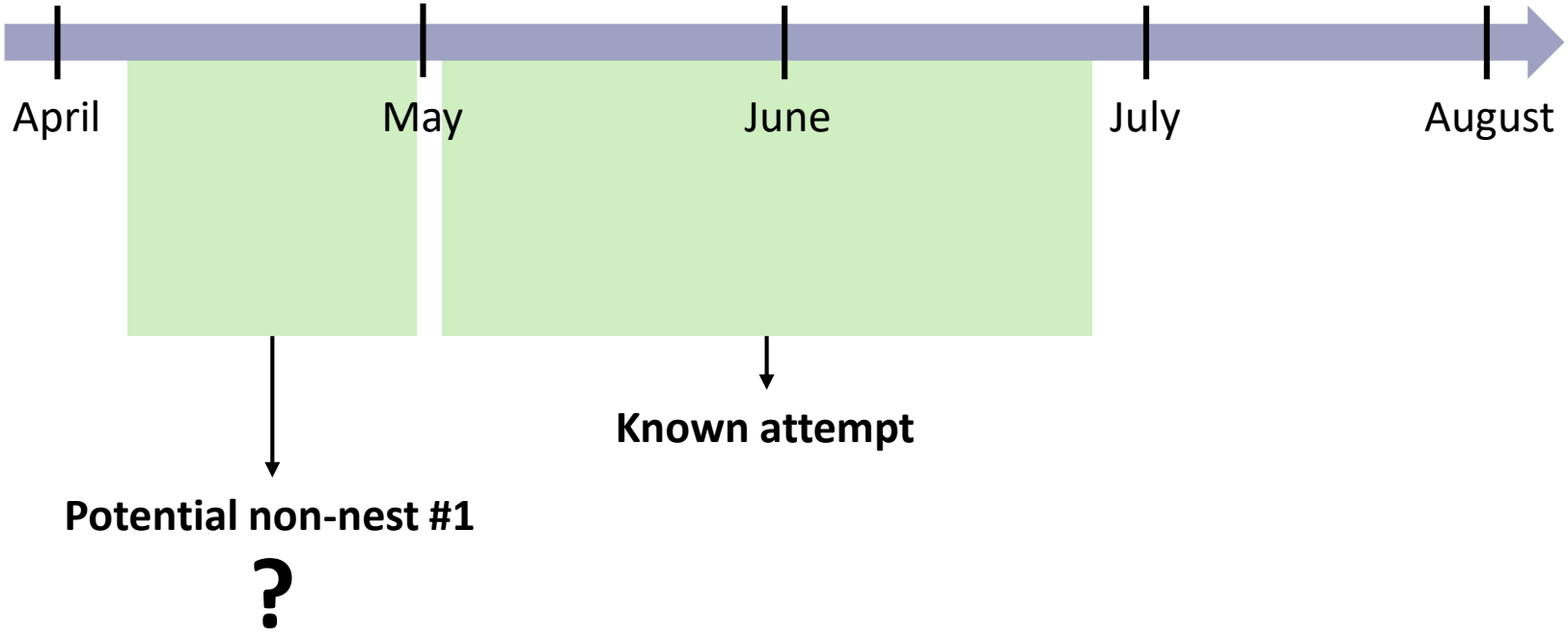

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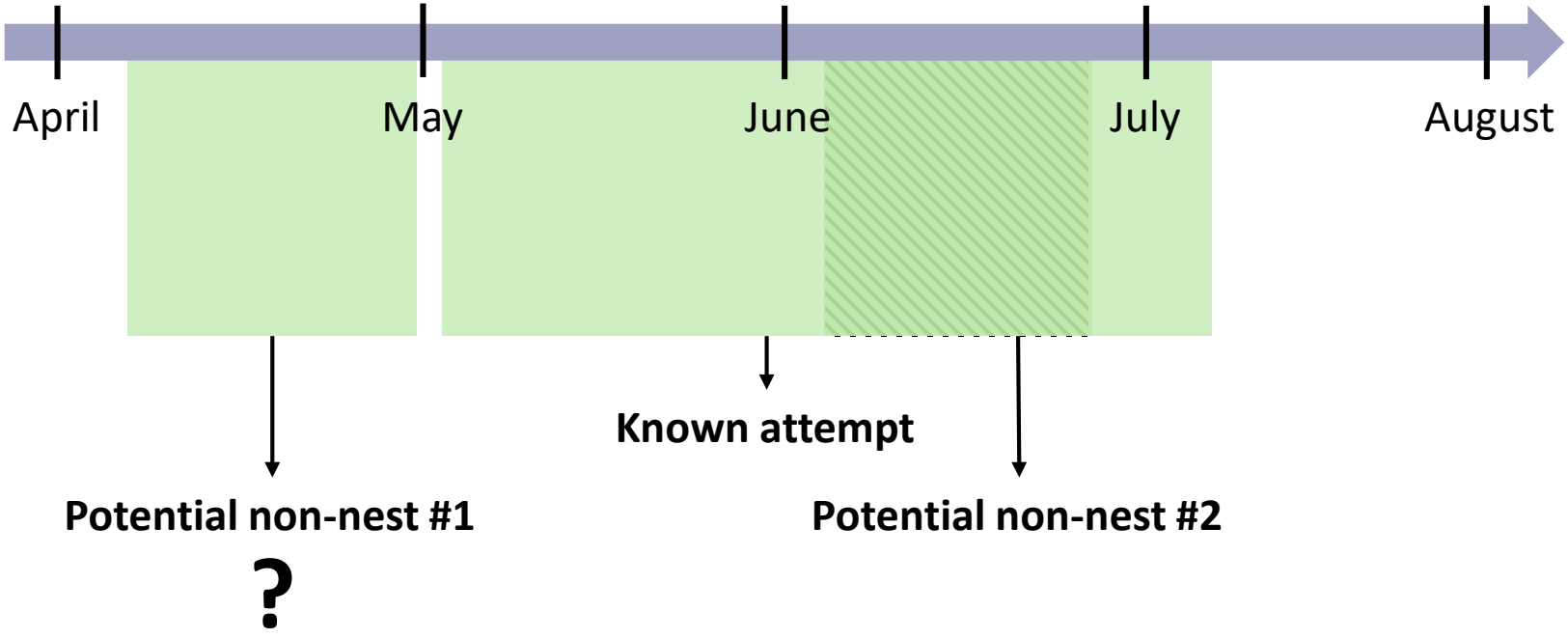

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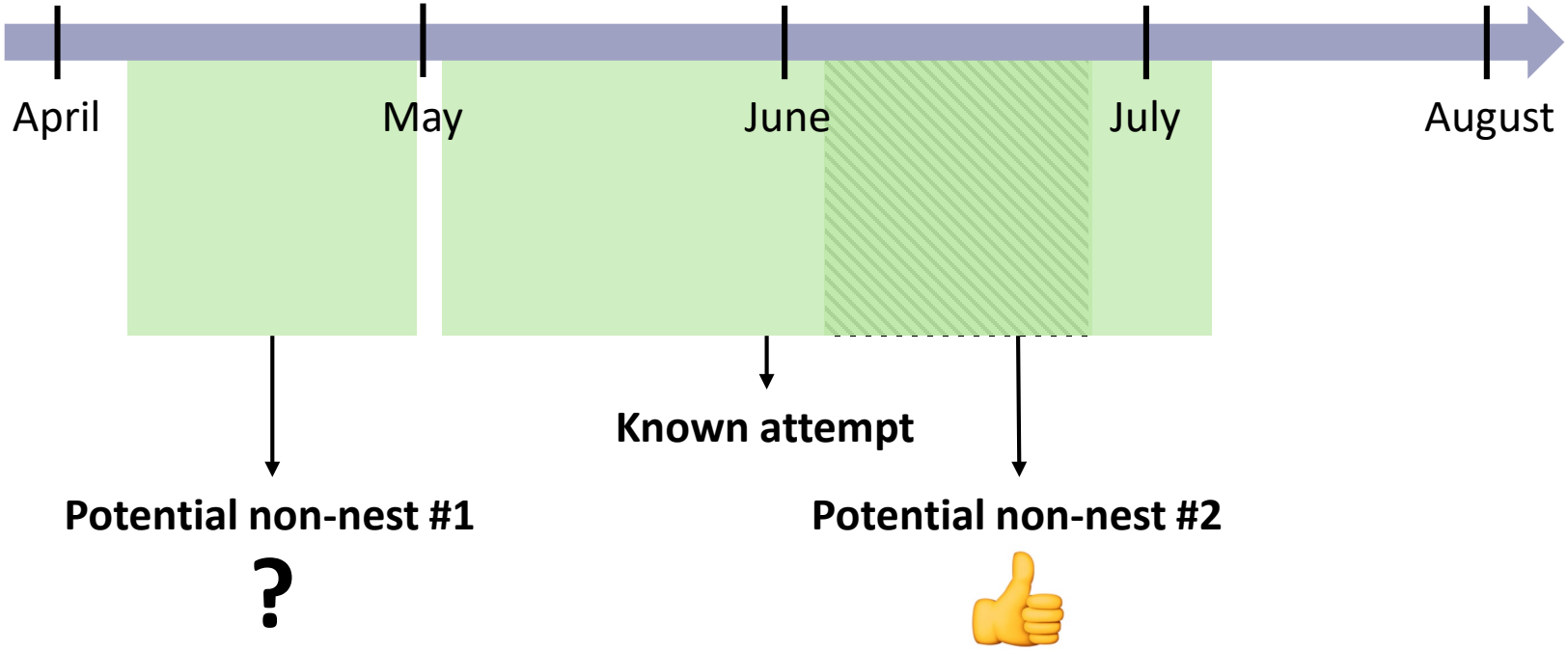

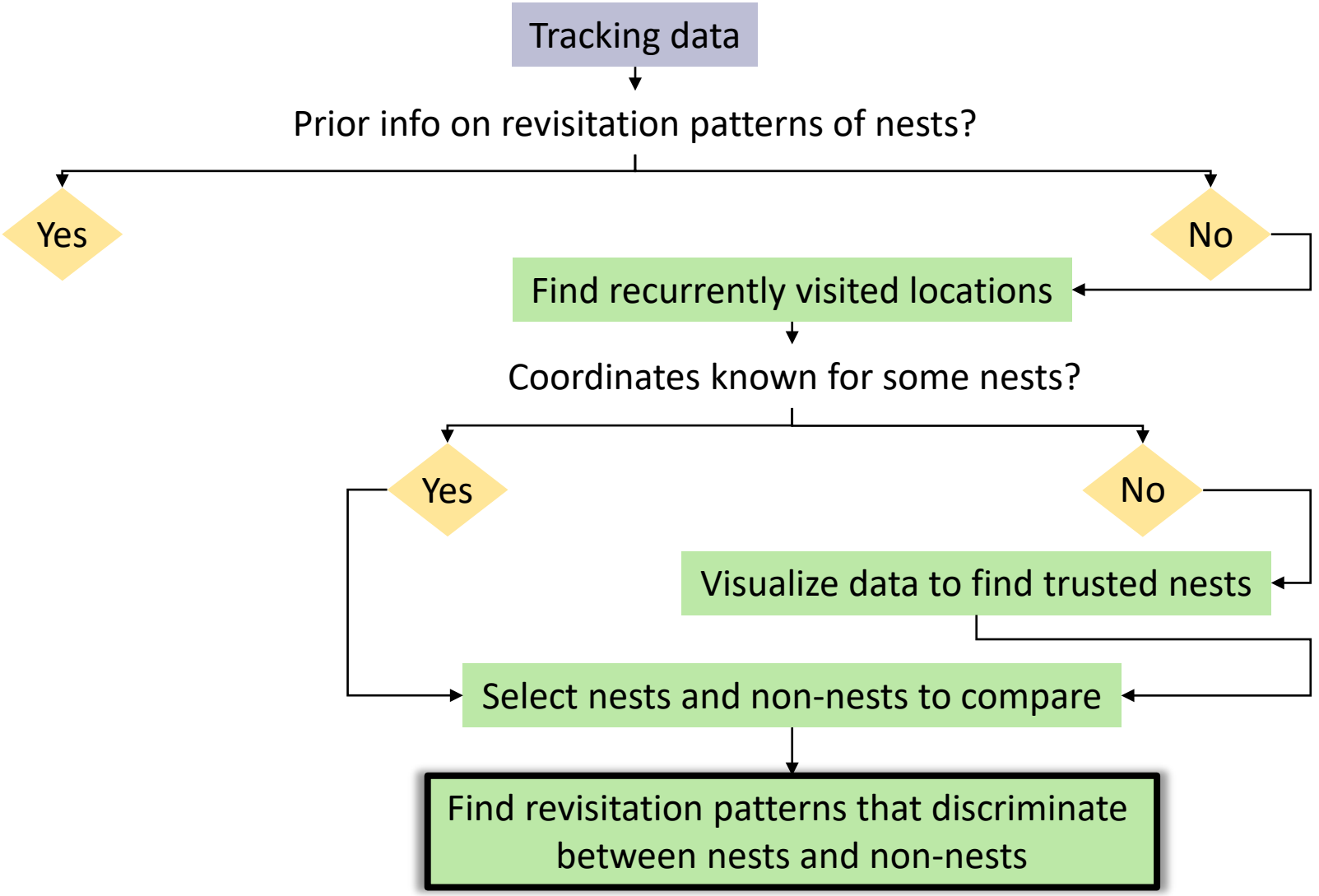
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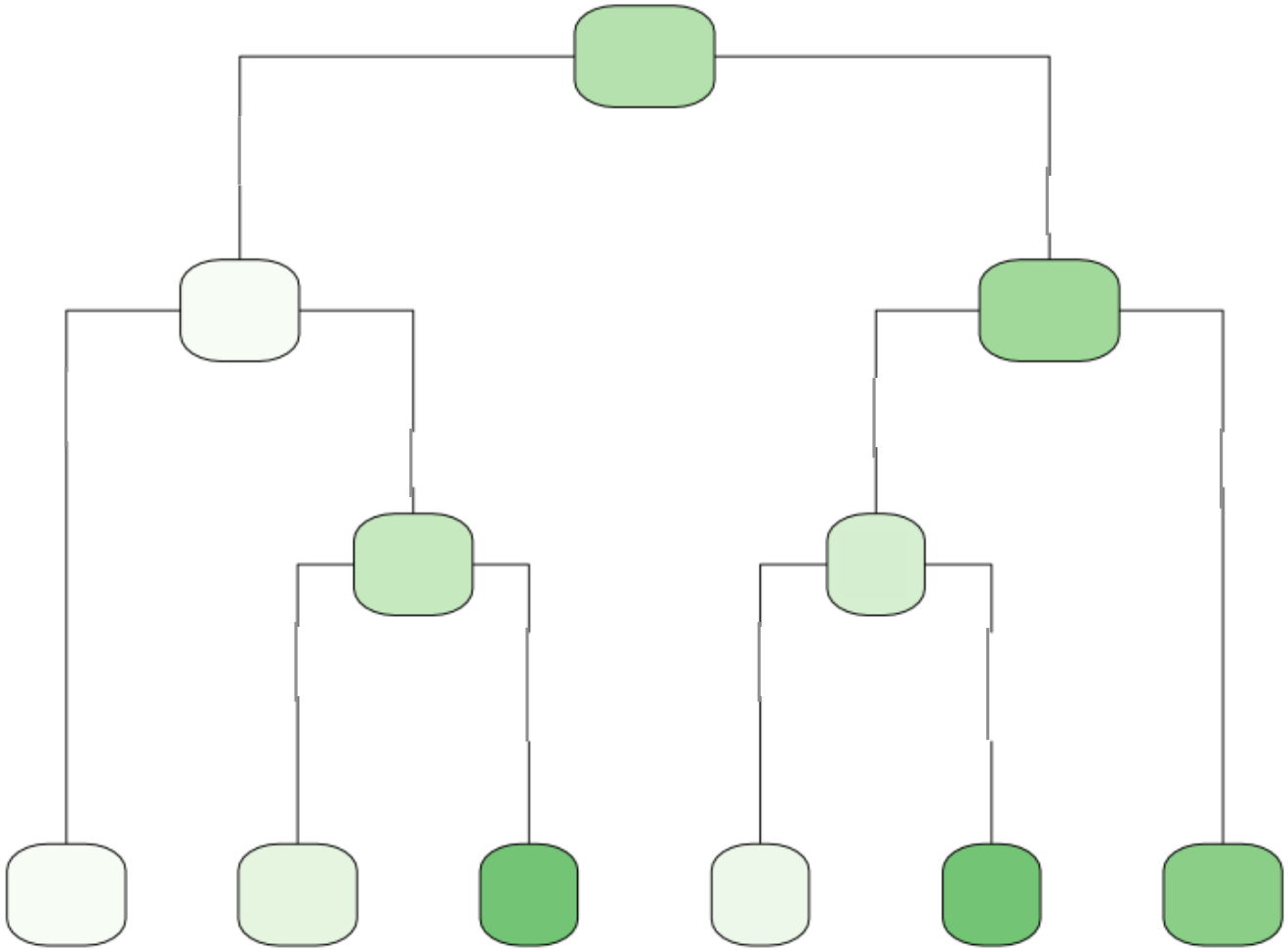
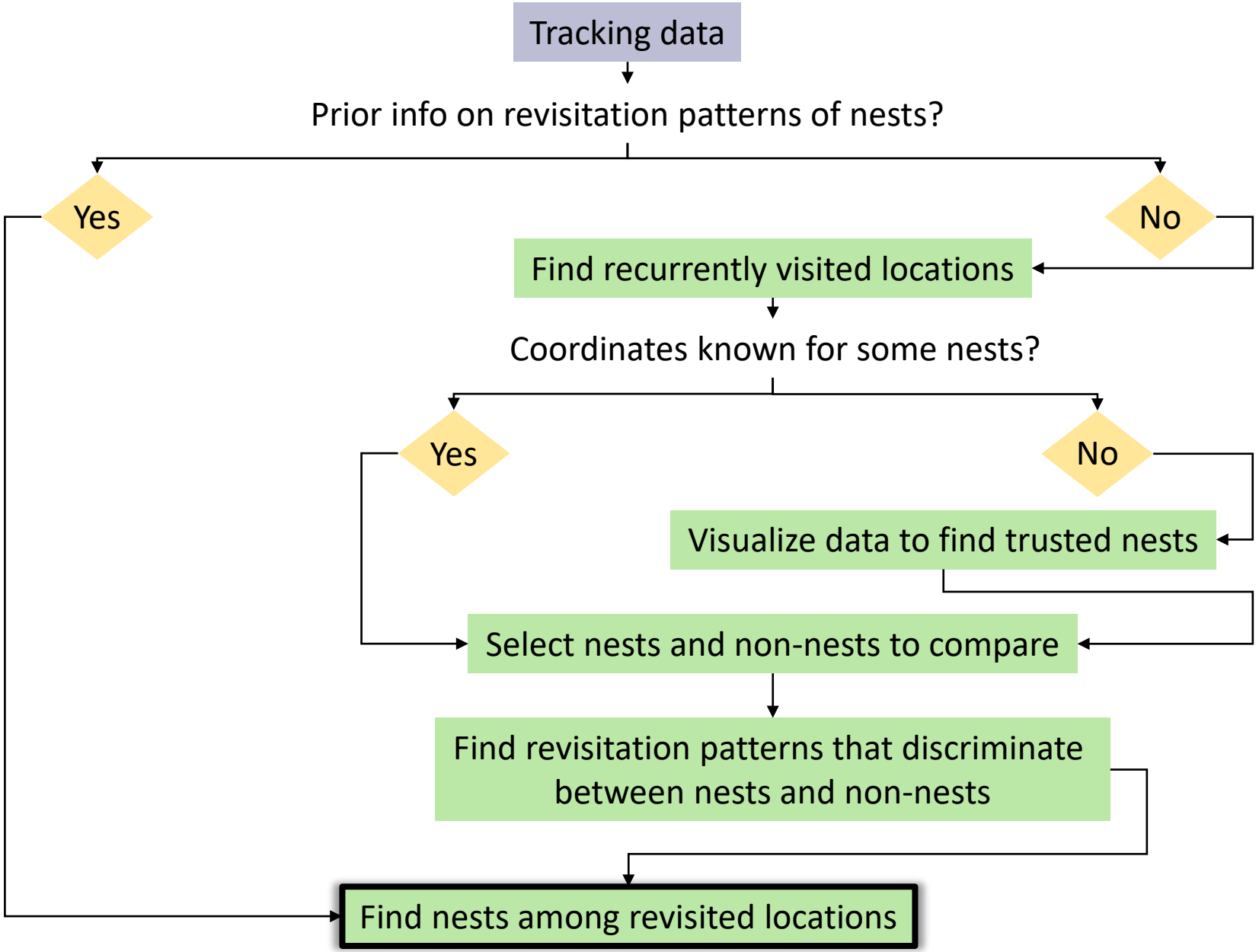
Discriminate between nests and non-nests

Classification And Regression Trees (CART)

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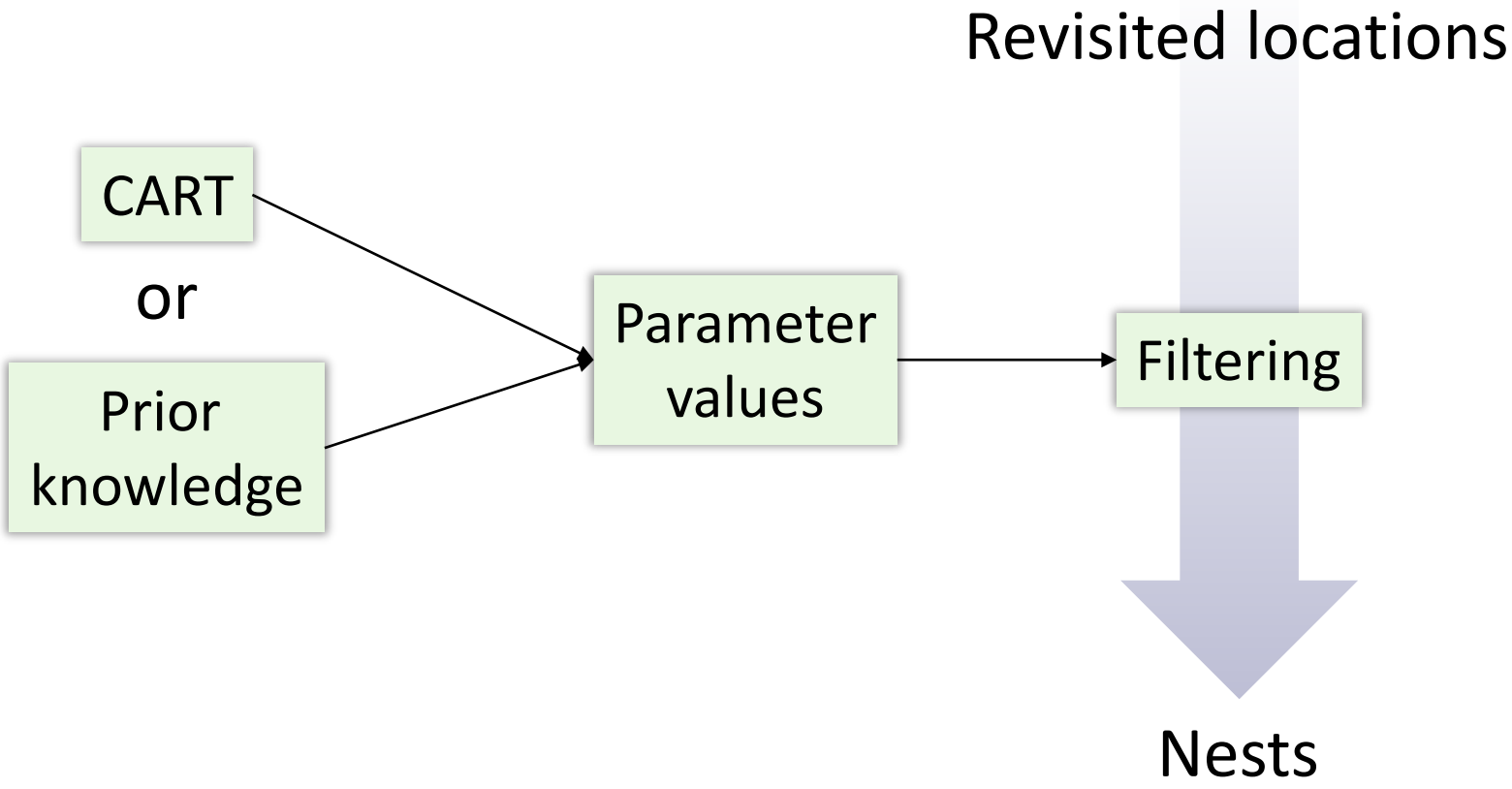

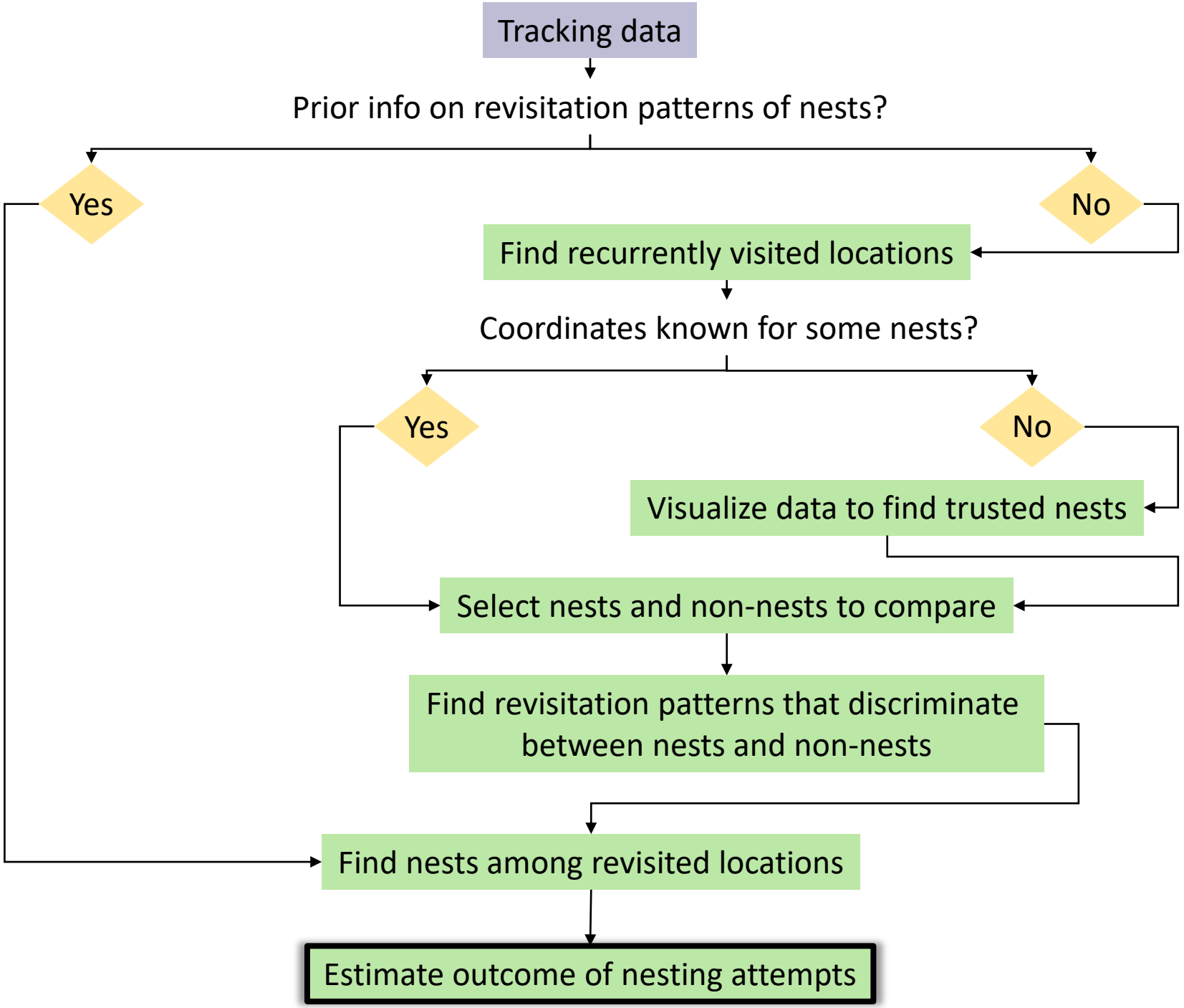
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t	1	2	3	4	…	T-3	T-2	T-1	T
Y	8	6	6	0	…	2	0	1	0
N	12	12	10	0	…	5	10	8	12

t → Day

Y → Nest visits

N → GPS fixes

Estimate outcome of nesting attempts

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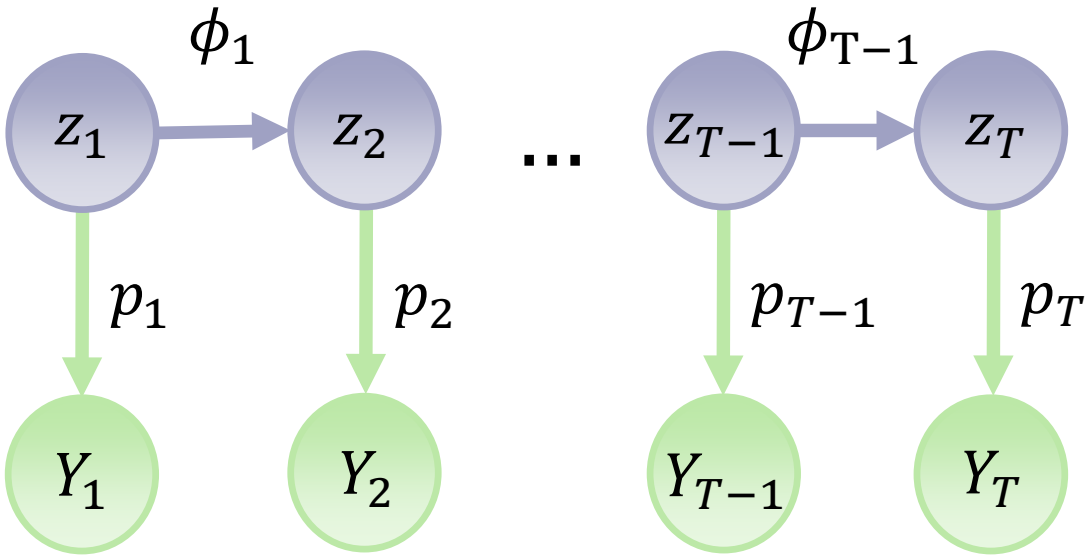
$z_t = 1$ → Alive

$z_t = 0$ → Dead



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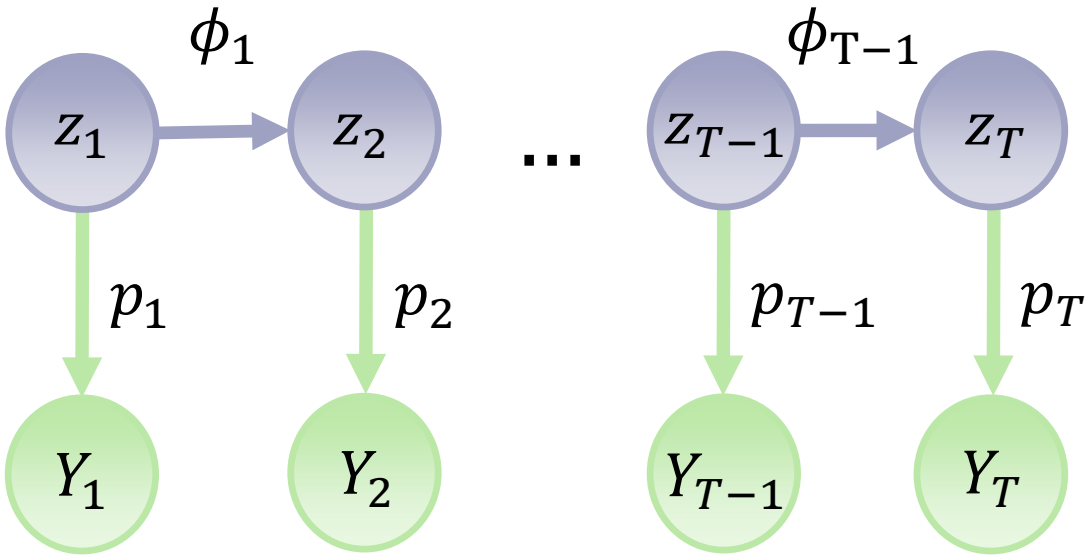
ϕ_t → Probability of survival

p_t → Probability of detection



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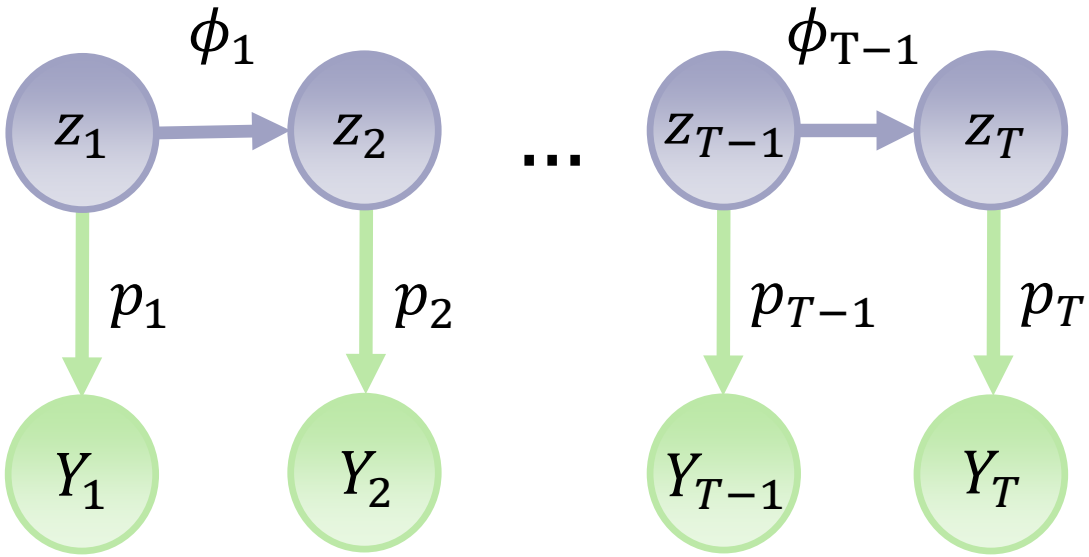

$z_t \sim Bern(z_{t-1} \times \phi_{t-1})$

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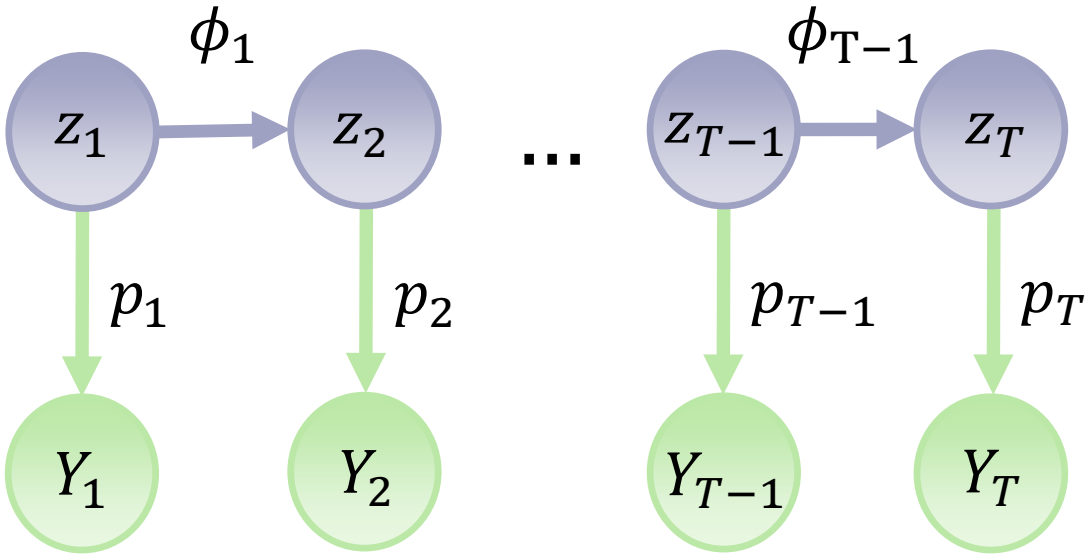

$z_t \sim Bern(z_{t-1} \times \phi_{t-1})$

$Y_t \sim Binom(z_t \times p_t, N_t)$

Takes into account:

- Missing data
- Missed visit detection

Estimate outcome of nesting attempts

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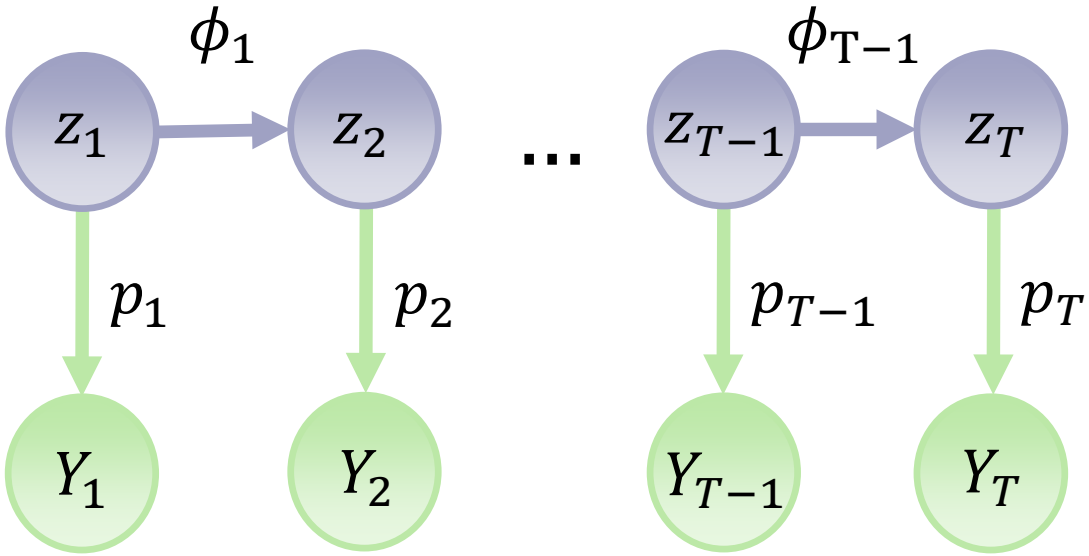

$$z_t \sim Bern(z_{t-1} \times \phi_{t-1})$$

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$$logit(\phi_t) = \beta_{\phi_0} + \beta_{\phi_1} \times t$$

$$logit(p_t) = \beta_{p_0} + \beta_{p_1} \times t$$

Takes into account:

- Missing data
- Missed visit detection
- Time-varying survival and detection

Application to Data

		Mediterranean gulls	Lesser kestrels	Wood storks
Temporal resolution (min)		15	15	60
Ground-truth		Loc. + Outcome	Loc. + Outcome	Location only
Number of tracks	Breeding	24	50	107
	Non-breeding	16	16	41
Tagged at		Incubation	Early chick-rearing	Non-breeding

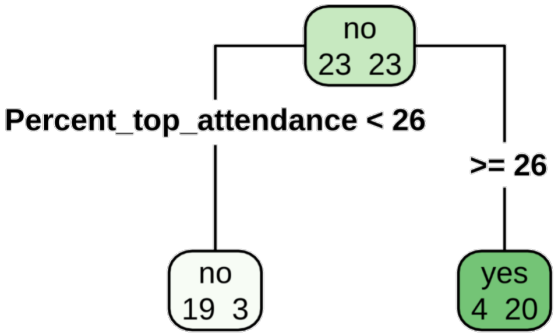
Number of revisited locations
(40 m buffer)

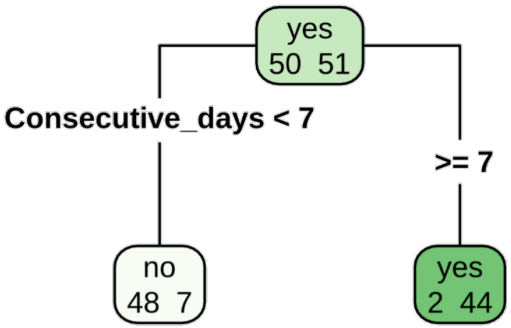
1379

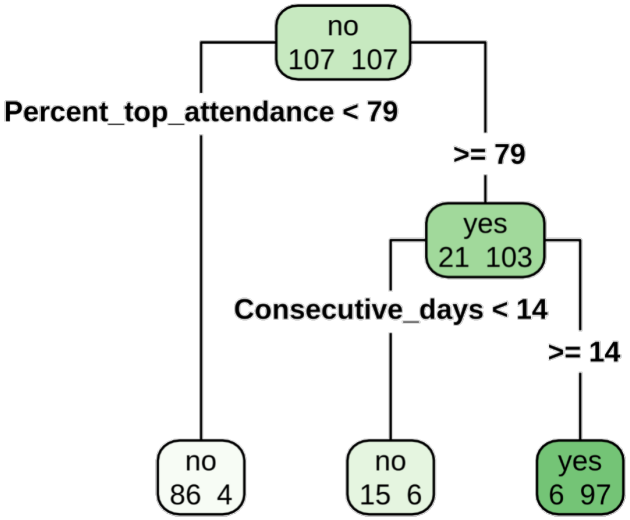
511

9871

CART output


no
23 23
Percent_top_attendance < 26
>= 26
no
19 3
yes
4 20


yes
50 51
Consecutive_days < 7
>= 7
no
48 7
yes
2 44


no
107 107
Percent_top_attendance < 79
>= 79
yes
21 103
Consecutive_days < 14
>= 14
no
86 4
no
15 6
yes
6 97

Number of nests found

Revisited locations

1379	511	9871
Filtering		
30	45	109

	Mediterranean gulls	Lesser kestrels	Wood storks
Positive Predictive Value	73%	100%	86%
Sensitivity	92%	90%	88%

$$PPV = \Pr(known|detected)$$

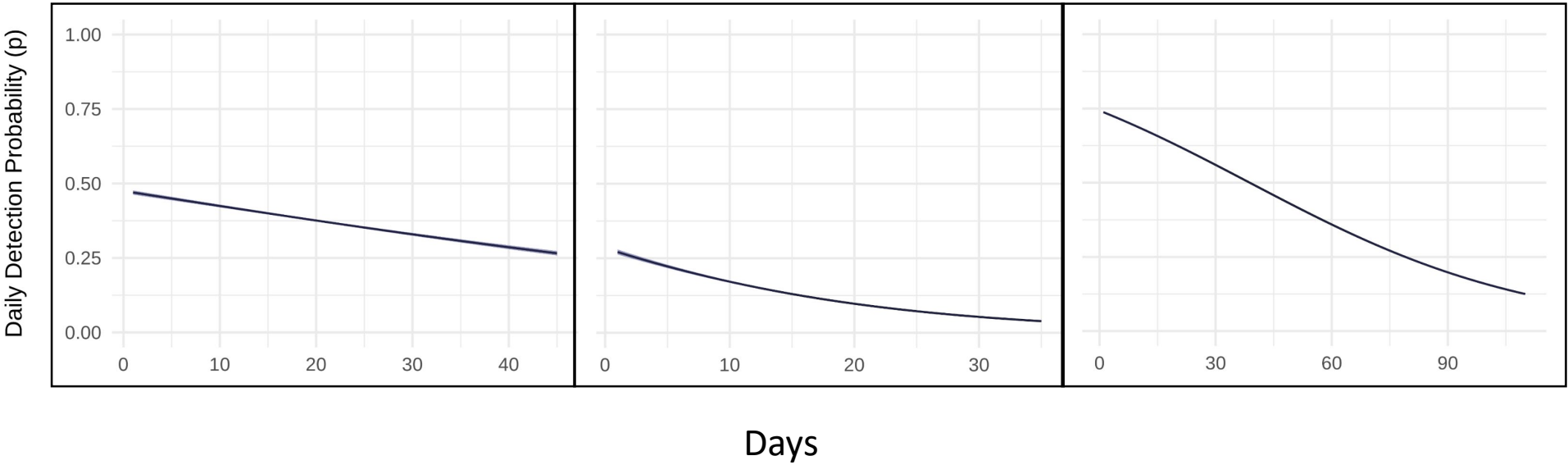
$$S = \Pr(detected|known)$$

	Mediterranean gulls	Lesser kestrels	Wood storks
False Negative Rate	8%	10%	12%
False Positive Rate	0%	44%	7%

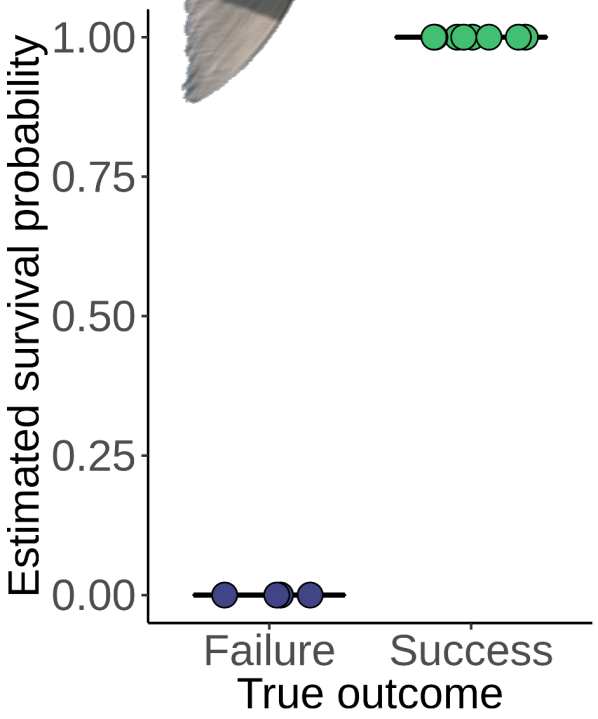
$$FNR = \Pr(not\ detected | known)$$

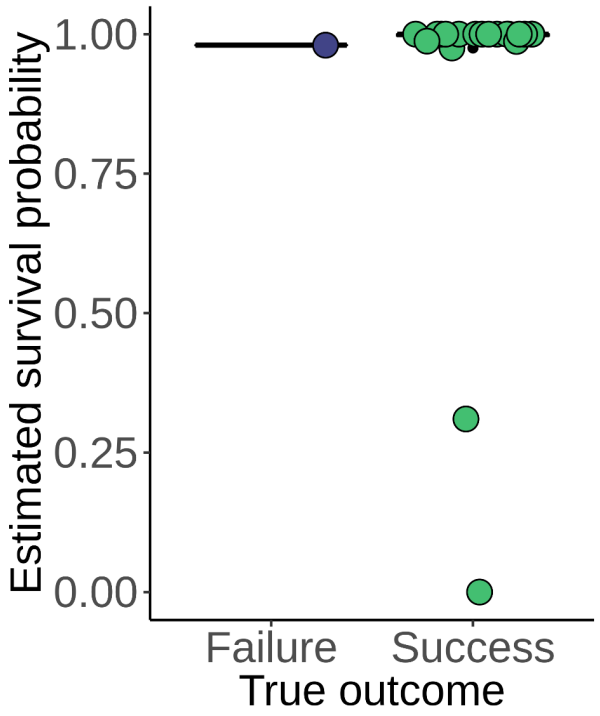
$$FPR = \Pr(detected | non\ breeder)$$

Probability of visit detection



Nest survival estimates





Conclusions

- Our method connects movement to reproductive success

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- Good performance despite data limitations
- Applicable to any GPS-trackable birds

Conclusions

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- Need to tailor the analysis according to data characteristics

Future improvements

- Incorporate uncertainty in nest detection

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Future improvements

- Incorporate uncertainty in nest detection
- Explicitly consider path geometry
- Identify nesting stages based on periodicity of visits

Thank you!


package ‘nestR’


@simopicardi


https://github.com/picardis/nestR


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