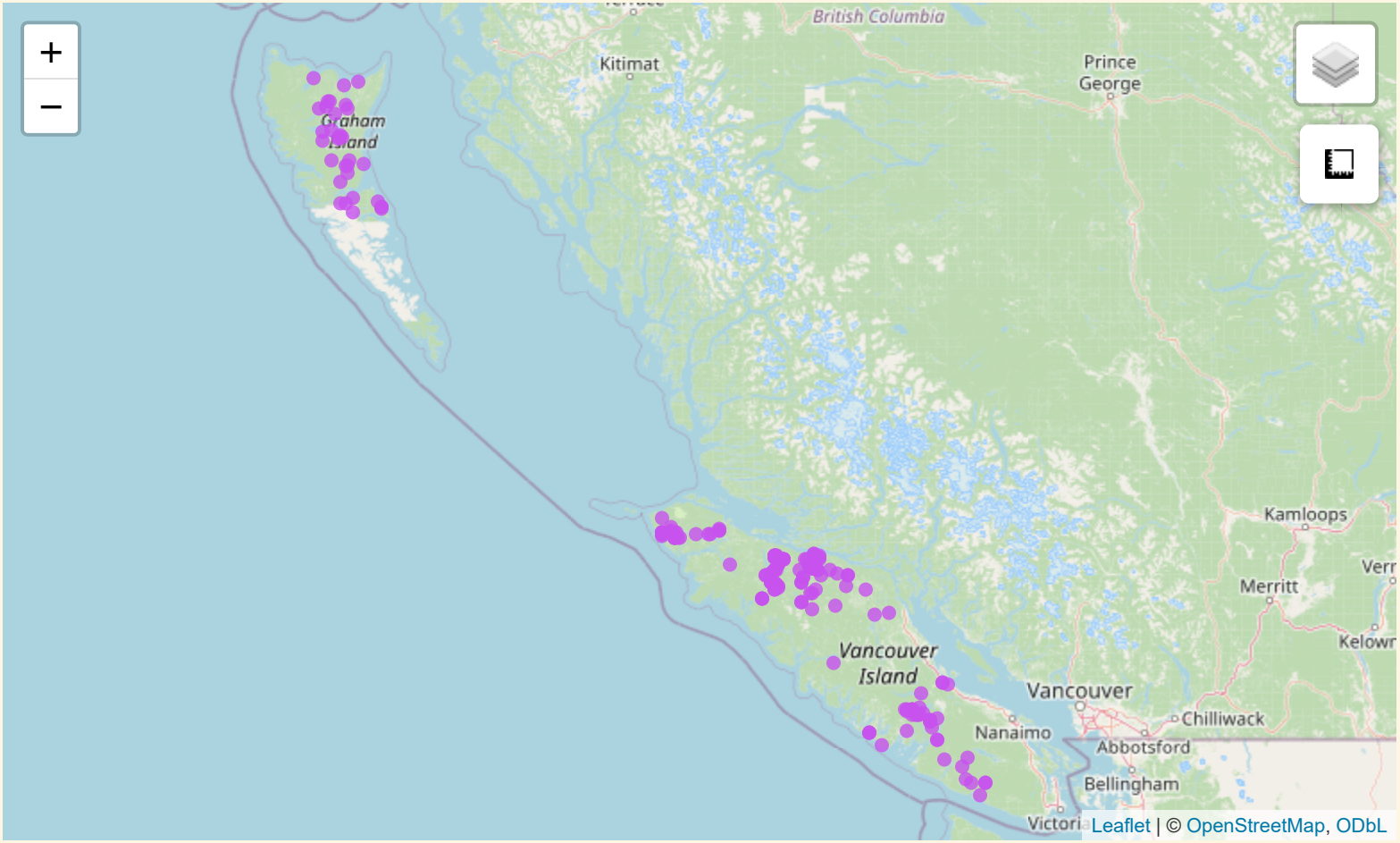
Bear Den Data Summary

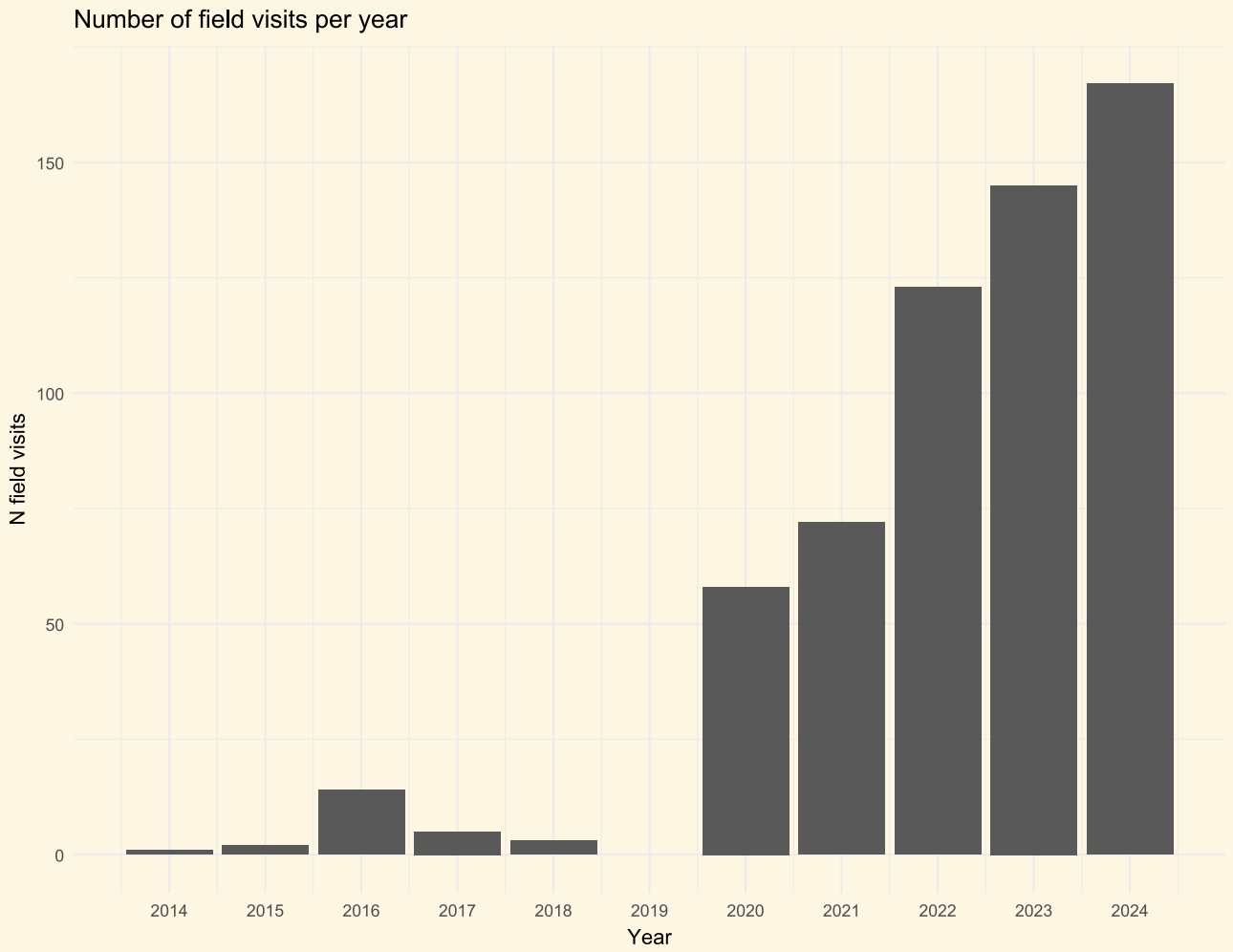
2025-04-02

There are currently **179** dens being tracked, and a total of **590** field visits completed to date (**2025-04-02**).

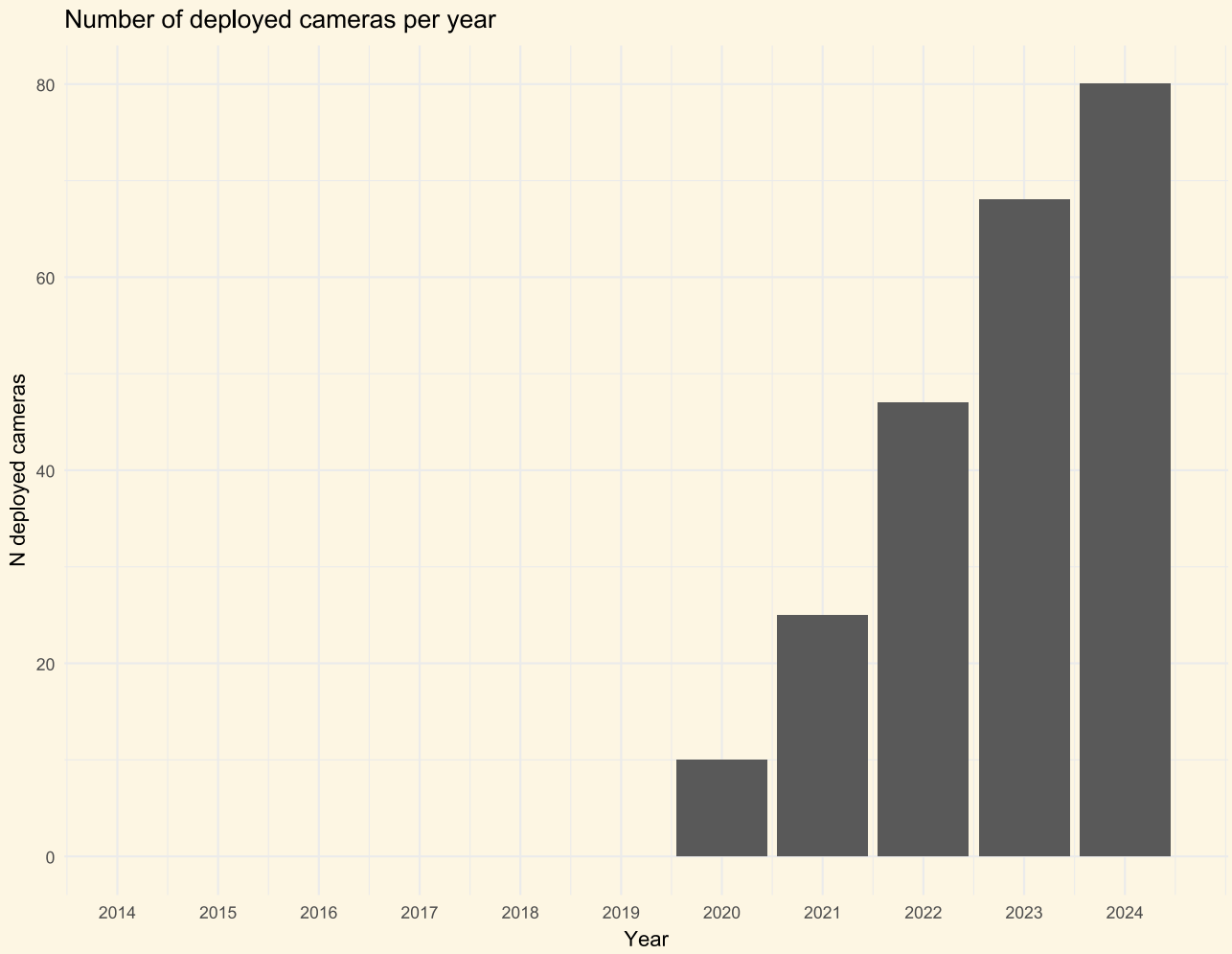


Use the menus on the top-right to change the basemap or perform measurements.

Overall summary



Overall summary

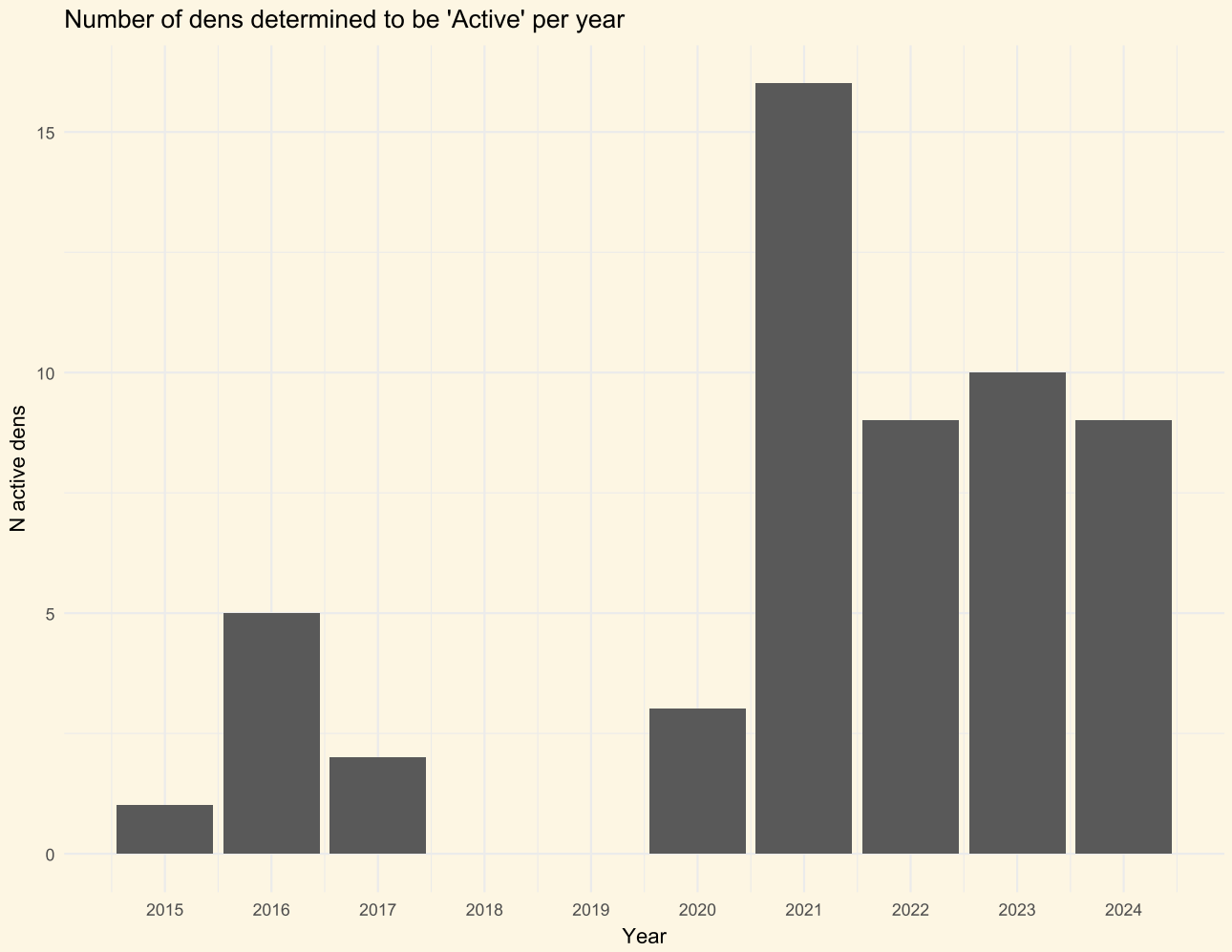


Overall summary

Den Status - what have we got?

Den Status	N
Active in last denning season	53
Active recently (0-4 seasons)	74
Currently active	2
No recent evidence of use (>4 seasons)	65
Not active in last season	85
Not active in last season, but recent use (1-4 seasons)	104
Not active in last season, no recent use (>4 seasons)	101
Obsolete	26
Unknown	80

Overall summary



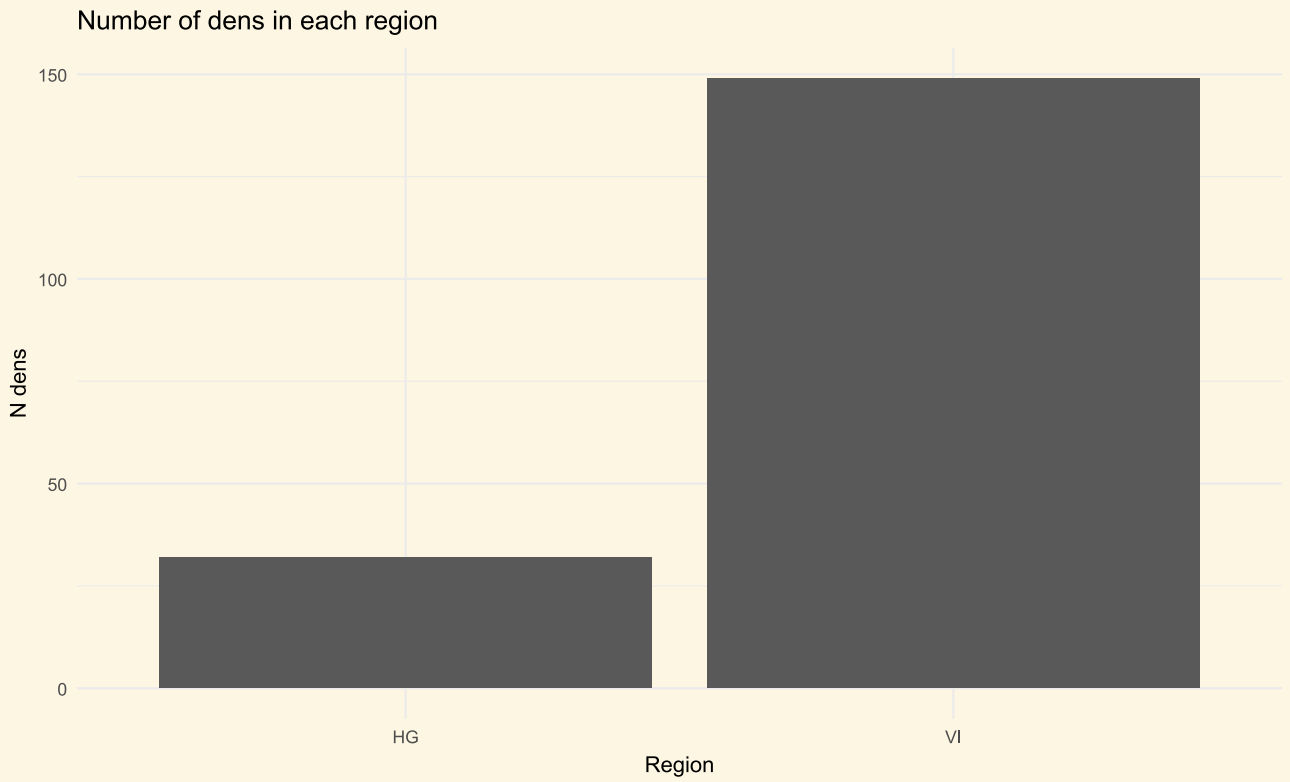
Where are our dens?

District

District	N
Campbell River	38
Haida Gwaii	32
North Island and Central Coast	74
South Island	37

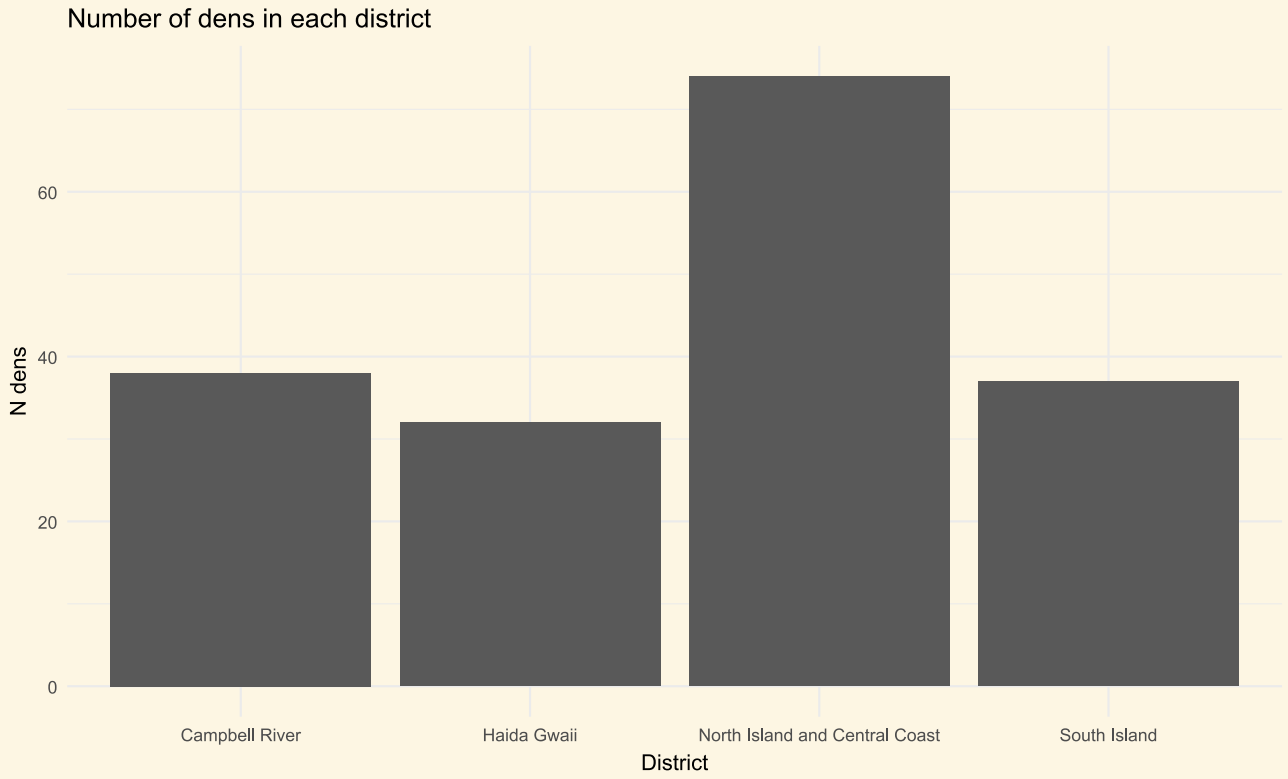
Where are our dens?

Region



Where are our dens?

District



What does a den look like?

What does a den look like?

Den Tree Species

Den Tree Species	N
Cw	102
Fd	4
Hm	3
Hw	17
Ss	5
Yc	44

What does a den look like?

Proportion by tree species

Den Tree Species	%
Cw	58
Fd	2
Hm	2
Hw	10
Ss	3
Yc	25

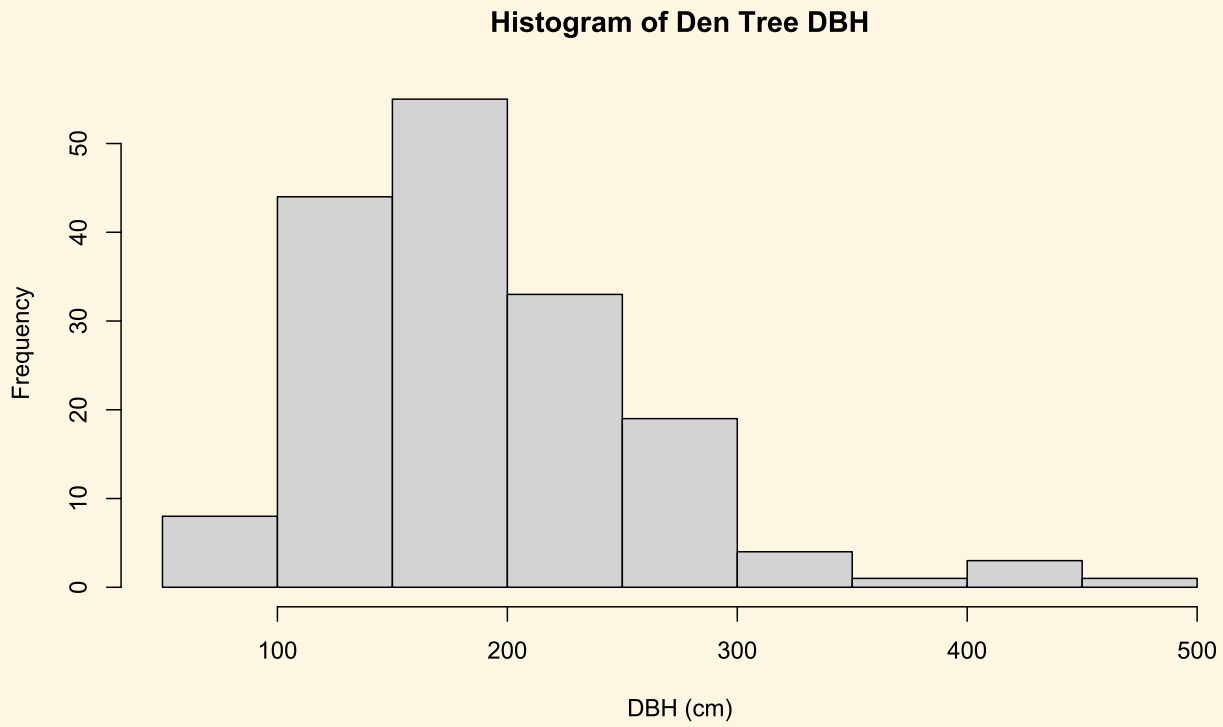
What does a den look like?

Den Type

Den Type	N
hollow stump	9
hollow tree, arboreal entrance	40
hollow tree, ground entrance	114
log (hollow or under in comments)	6
other including artificial (type in comments)	3
root bole, downed tree	1
root bole/root wad	3
root structure, standing tree, standing tree	2

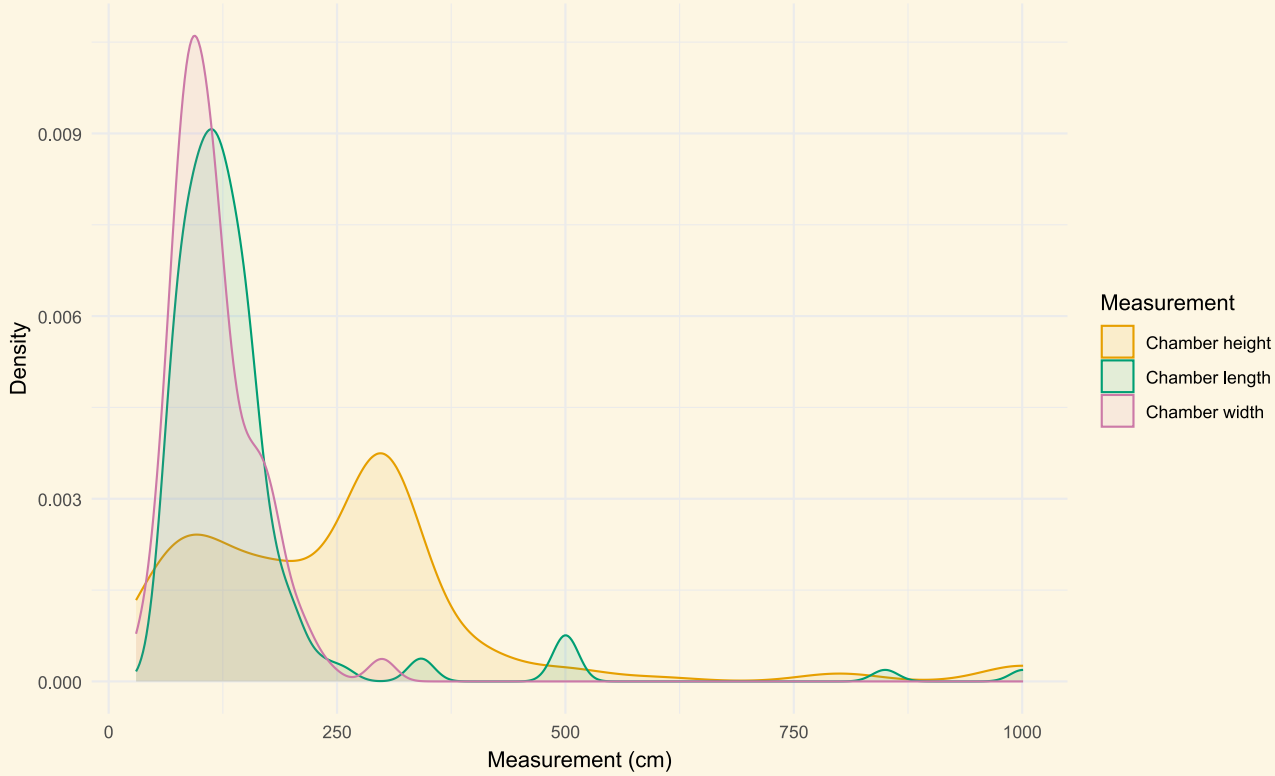
What does a den look like?

DBH



What does a den look like?

Chamber width, height, and length



What does a den look like?

Dens with Bed Cups during each field visit (N)

Bedding Cup Present?	N
No	109
Unknown	84
Yes	346
Yes - Unchanged	36

What does a den look like?

Dens with Bed Cups during each field visit (%)

Bedding Cup Present?	%
No	19
Unknown	15
Yes	60
Yes - Unchanged	6

What does a den look like?

What proporion of dens have certain bedding materials?

Material	N dens	% dens
Salal	40	22%
Ferns	26	15%
Moss	58	32%
Cedar/Hemlock	52	29%
Needles	61	34%
Twigs/Branches	91	51%
Duff	36	20%
Scrapings	89	50%
No imported material	28	16%

What does a den look like?

Hair in Den during each field visit (N)

Hair in Den?	N
No	147
Unknown	262
Yes	141
Yes - Unchanged	14

What does a den look like?

Hair in Den during each field visit (%)

Hair in Den?	%
No	26
Unknown	46
Yes	25
Yes - Unchanged	2

What does a den look like?

Hair on Entrance during each field visit (N)

Hair on Entrance?	N
No	176
Unknown	55
Yes	316
Yes - Unchanged	28

What does a den look like?

Hair on Entrance during each field visit (%)

Hair on Entrance?	%
No	31
Unknown	10
Yes	55
Yes - Unchanged	5

What does a den look like?

Age Class

Age Class	N
1: 0-20	26
3: 41-60	6
4: 61-80	8
5: 81-100	2
6: 101-120	3
7: 121-140	9
8: 141-250	11
9: >250	96
Unknown	7
upper slope	1

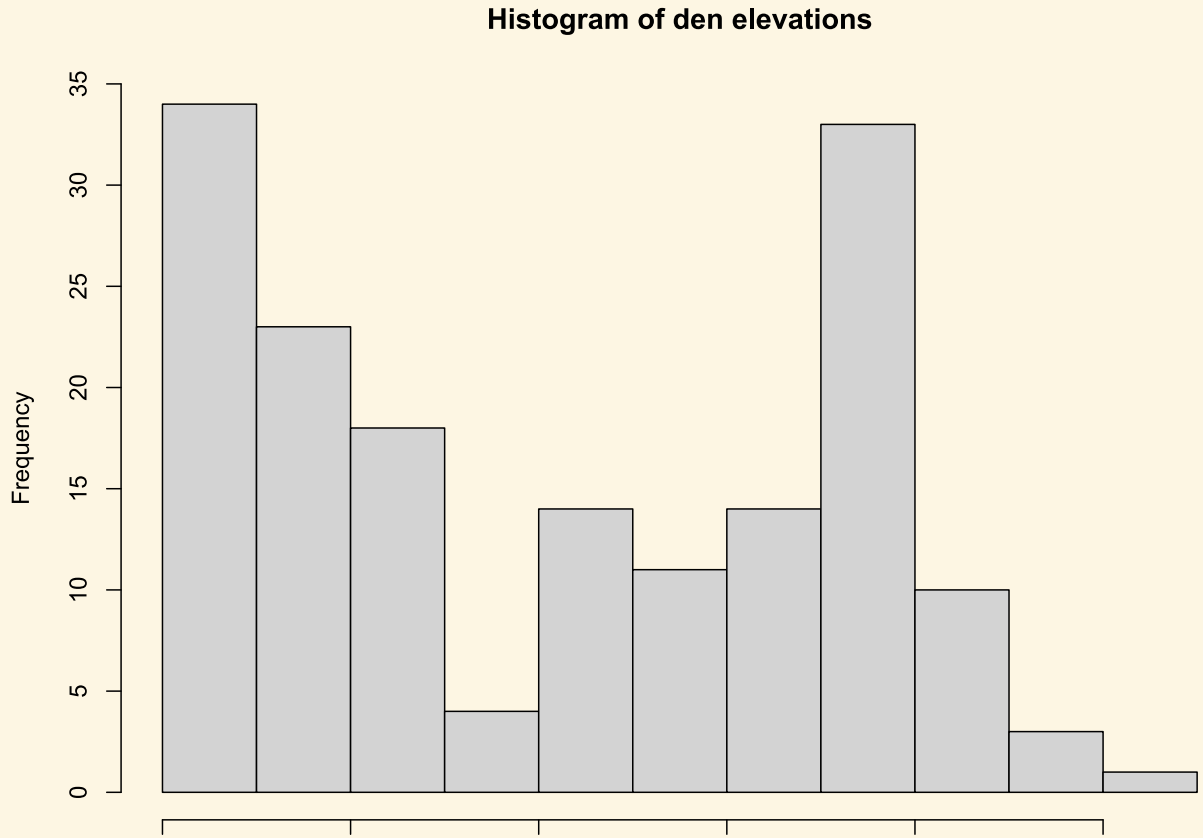
What does a den look like?

Den State (initial visit)

Den State	N
Confirmed (functional den)	121
Obsolete (no longer functional)	14
Unsure (needs more monitoring)	40

What's the geography like?

Elevation



Den Status

Rates of Re-Use

Den Status - what have we got?

Den Status	N
Active in last denning season	53
Active recently (0-4 seasons)	74
Currently active	2
No recent evidence of use (>4 seasons)	65
Not active in last season	85
Not active in last season, but recent use (1-4 seasons)	104
Not active in last season, no recent use (>4 seasons)	101
Obsolete	26
Unknown	80

"Active"

Dens with the highlighted status were considered "confirmed active" within the last season.

Den Status	N
Active in last denning season	**53**
Active recently (0-4 seasons)*	**74**
Currently active	**2**
No recent evidence of use (>4 seasons)	65
Not active in last season	85
Not active in last season, but recent use (1-4 seasons)	104
Not active in last season, no recent use (>4 seasons)	101
Obsolete	26
Unknown	80

* If the first datapoint in the timeseries was `Active recently (0-4 seasons)`, we counted it as `Active` (*N* = 58).

"Non-Active"

Dens with the highlighted status were considered "confirmed *not* active" within the last season.

Den Status	N
Active in last denning season	53
Active recently (0-4 seasons)*	74
Currently active	2
No recent evidence of use (>4 seasons)	**65**
Not active in last season	**85**
Not active in last season, but recent use (1-4 seasons)	**104**
Not active in last season, no recent use (>4 seasons)	**101**
Obsolete	26
Unknown	80

* If the first datapoint in the timeseries was `Active recently (0-4 seasons)`, we counted it as `Active` (*N* = 58).

"Unknown/Obsolete"

Dens with the highlighted status were excluded from den status assessments.

Den Status	N
Active in last denning season	53
Active recently (0-4 seasons)*	**74**
Currently active	2
No recent evidence of use (>4 seasons)	65
Not active in last season	85
Not active in last season, but recent use (1-4 seasons)	104
Not active in last season, no recent use (>4 seasons)	101
Obsolete	**26**
Unknown	**80**

* If the first datapoint in the timeseries was `Active recently (0-4 seasons)`, we counted it as `Active` (*N* = 58).

All statuses

Dens with the highlighted status were excluded from den status assessments.

Den Status	N
Active in last denning season	53
Active recently (0-4 seasons)*	**74**
Currently active	2
No recent evidence of use (>4 seasons)	65
Not active in last season	85
Not active in last season, but recent use (1-4 seasons)	104
Not active in last season, no recent use (>4 seasons)	101
Obsolete	**26**
Unknown	**80**

* If the first datapoint in the timeseries was `Active recently (0-4 seasons)`, we counted it as `Active` (*N* = 58).

Rates of re-use

First need to categorize dens into `Active`, `Not Active`, or `Unknown`. Based on the highlighted rows in the tables of the previous slides, we have:

den_status	den_status_binary
Active in last denning season	Active
Currently active	Active
No recent evidence of use (>4 seasons)	Not Active
Not active in last season, no recent use (>4 seasons)	Not Active
Not active in last season	Not Active
Not active in last season, but recent use (1-4 seasons)	Not Active
Obsolete	Obsolete
Unknown	Unknown
Active recently (0-4 seasons)	Unknown

Rates of re-use

First need to categorize dens into `Active`, `Not Active`, or `Unknown`. Based on the highlighted rows in the tables of the previous slides, we have:

Den Status	N
Active	55
Not Active	355
Obsolete	26
Unknown	154

Total number of visits = **590**

Rates of re-use

First need to categorize dens into `Active`, `Not Active`, or `Unknown`. Based on the highlighted rows in the tables of the previous slides, we have:

Den Status	%
Active	9
Not Active	60
Obsolete	4
Unknown	26

Total number of visits = **590**

Rates of re-use

For now, I'm counting `Unknowns` the same as `Not Active`.

This is a quick and dirty assignment of 're-use' - it doesn't take into account if there's been a large temporal gap (e.g., years) between visits.

But, essentially, if the status was `Active` for two records in a row, it's counted as *re-used*.

Rates of re-use

Show 8 entries Search:

	den_id	sample_id	date_inspected	cumulative_visit	den_status_binary	reuse_yn	consecutiveuse_yn
1	ADA_EveRiver_1	ADA_EveRiver_1_20201001	2020-10-01T07:00:00Z	1	Not Active	false	
2	ADA_EveRiver_1	ADA_EveRiver_1_20210916	2021-09-17T01:26:57Z	2	Not Active	false	false
3	ADA_EveRiver_1	ADA_EveRiver_1_20220922	2022-09-23T03:00:02Z	3	Not Active	false	false
4	ADA_EveRiver_1	ADA_EveRiver_1_20230829	2023-08-30T04:21:08Z	4	Not Active	false	false
5	ADA_EveRiver_1	ADA_EveRiver_1_20240816	2024-08-17T03:53:12Z	5	Not Active	false	false
6	ADA_EveRiver_2	ADA_EveRiver_2_20161102	2016-11-02T07:00:00Z	1	Not Active	false	
7	ADA_EveRiver_2	ADA_EveRiver_2_20201001	2020-10-01T07:00:00Z	2	Not Active	false	false
8	ADA_EveRiver_2	ADA_EveRiver_2_20211120	2021-11-20T08:09:03Z	3	Active	false	false

Showing 1 to 8 of 590 entries

Previous 1 2 3 4 5 ... 74 Next

Rates of re-use

Number of dens never used

Number of times den was Active	N dens
0	136
1	32
2	10
3	1

Rates of re-use

Number of dens never used

Number of times den was Active	%
0	76
1	18
2	6
3	1

Rates of re-use

Number of consecutive re-uses

Den was re-used two years in a row

Re-Used Consecutively (T/F)	N
FALSE	405
TRUE	6
NA	179

Note that `NA` signifies the first visit to a den - we don't know if `reuse_yn == TRUE` or `FALSE` bc it's the first visit

Rates of re-use

Percent of consecutive use

Den was re-used two years in a row

Re-Used Consecutively (T/F)	%
FALSE	69
TRUE	1
NA	30

Note that `NA` signifies the first visit to a den - we don't know if `reuse_yn == TRUE` or `FALSE` bc it's the first visit

Rates of re-use

A few example dens...

Rates of re-use

ADA_EveRiver_1

Was never active in the first place.

den_id	sample_id	date_inspected	cumulative_visit	den_status_binary	reuse_yn
ADA_EveRiver_1	ADA_EveRiver_1_20201001	2020-10-01 00:00:00	1	Not Active	FALSE
ADA_EveRiver_1	ADA_EveRiver_1_20210916	2021-09-16 18:26:57	2	Not Active	FALSE
ADA_EveRiver_1	ADA_EveRiver_1_20220922	2022-09-22 20:00:02	3	Not Active	FALSE
ADA_EveRiver_1	ADA_EveRiver_1_20230829	2023-08-29 21:21:08	4	Not Active	FALSE
ADA_EveRiver_1	ADA_EveRiver_1_20240816	2024-08-16 20:53:12	5	Not Active	FALSE

Rates of re-use

COU_CousCreek_2

Active more than once, but not two years in a row.

den_id	sample_id	date_inspected	cumulative_visit	den_status_binary	reuse_yn
COU_CousCreek_2	COU_CousCreek_2_20170912	2017-09-12 00:00:00	1	Active	TRUE
COU_CousCreek_2	COU_CousCreek_2_20200929	2020-09-29 00:00:00	2	Unknown	TRUE
COU_CousCreek_2	COU_CousCreek_2_20210901	2021-09-01 18:54:03	3	Not Active	TRUE
COU_CousCreek_2	COU_CousCreek_2_20220901	2022-09-01 17:48:04	4	Active	TRUE
COU_CousCreek_2	COU_CousCreek_2_20230905	2023-09-05 21:11:11	5	Not Active	TRUE
COU_CousCreek_2	COU_CousCreek_2_20240919	2024-09-19 17:47:16	6	Not Active	TRUE

Rates of re-use

TSI_MountRussell_2

Was active, but then turned `Obsolete`.

den_id	sample_id	date_inspected	cumulative_visit	den_status_binary	reuse_yn
TSI_MountRussell_2	TSI_MountRussell_2_20160407	2016-04-07 00:00:00	1	Active	FALSE
TSI_MountRussell_2	TSI_MountRussell_2_20201007	2020-10-07 00:00:00	2	Obsolete	FALSE
TSI_MountRussell_2	TSI_MountRussell_2_20210623	2021-06-23 19:00:11	3	Obsolete	FALSE
TSI_MountRussell_2	TSI_MountRussell_2_20220915	2022-09-15 20:24:12	4	Obsolete	FALSE
TSI_MountRussell_2	TSI_MountRussell_2_20230830	2023-08-30 20:27:23	5	Obsolete	FALSE
TSI_MountRussell_2	TSI_MountRussell_2_20240917	2024-09-17 19:42:56	6	Obsolete	FALSE

Rates of re-use

SAN_RonningCreek_2

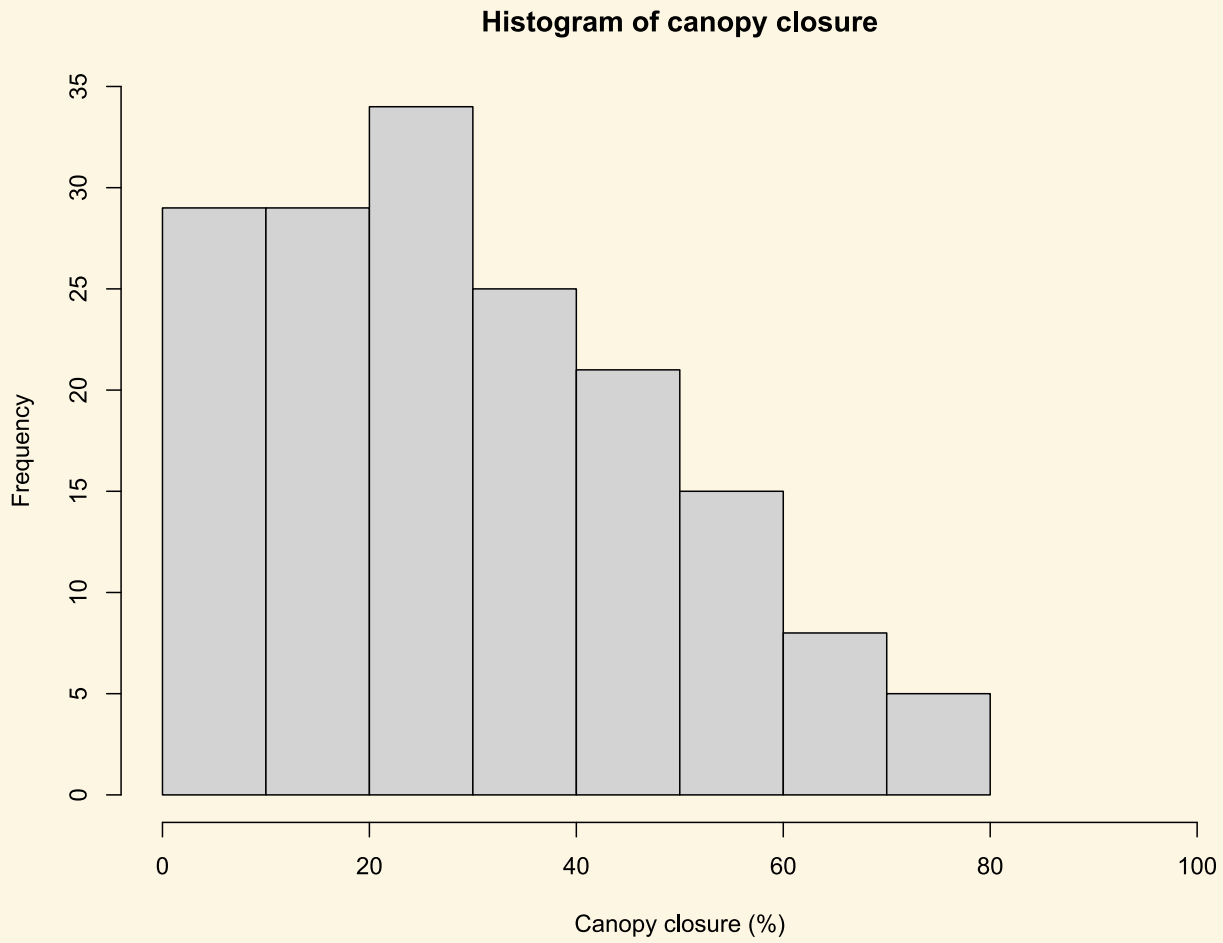
Active for two years in a row!

den_id	sample_id	date_inspected	cumulative_visit	den_status_binary	reuse_yn
SAN_RonningCreek_2	SAN_RonningCreek_2_20201006	2020-10-06 00:00:00	1	Unknown	TRUE
SAN_RonningCreek_2	SAN_RonningCreek_2_20210706	2021-07-06 17:14:22	2	Active	TRUE
SAN_RonningCreek_2	SAN_RonningCreek_2_20220621	2022-06-21 20:08:03	3	Active	TRUE
SAN_RonningCreek_2	SAN_RonningCreek_2_20230814	2023-08-14 17:01:09	4	Not Active	TRUE
SAN_RonningCreek_2	SAN_RonningCreek_2_20240920	2024-09-20 20:15:12	5	Active	TRUE

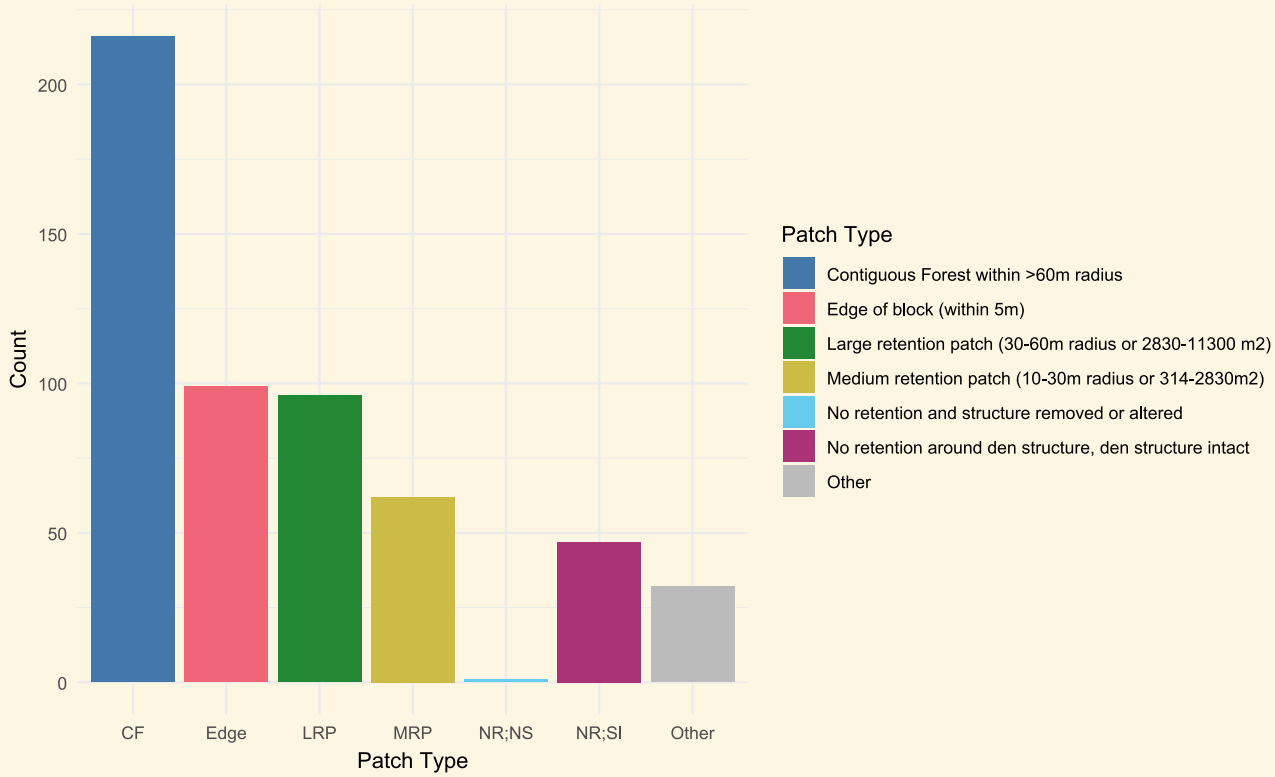
Forestry summary data

Canopy closure

Note this value was not updated past the first field visit.



Patch Type

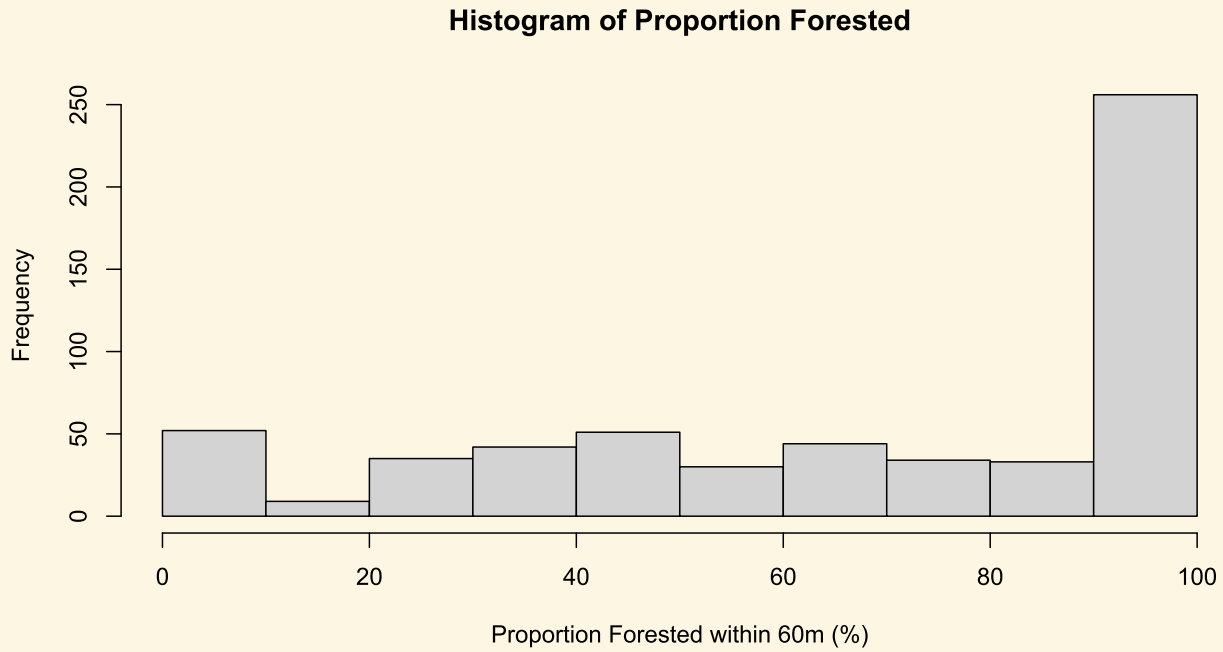


Note that not all dens have patch size categorized (N = 553 out of 590).

Proportion forested within 60m

Note this includes all field visits, including dens with repeated visits.

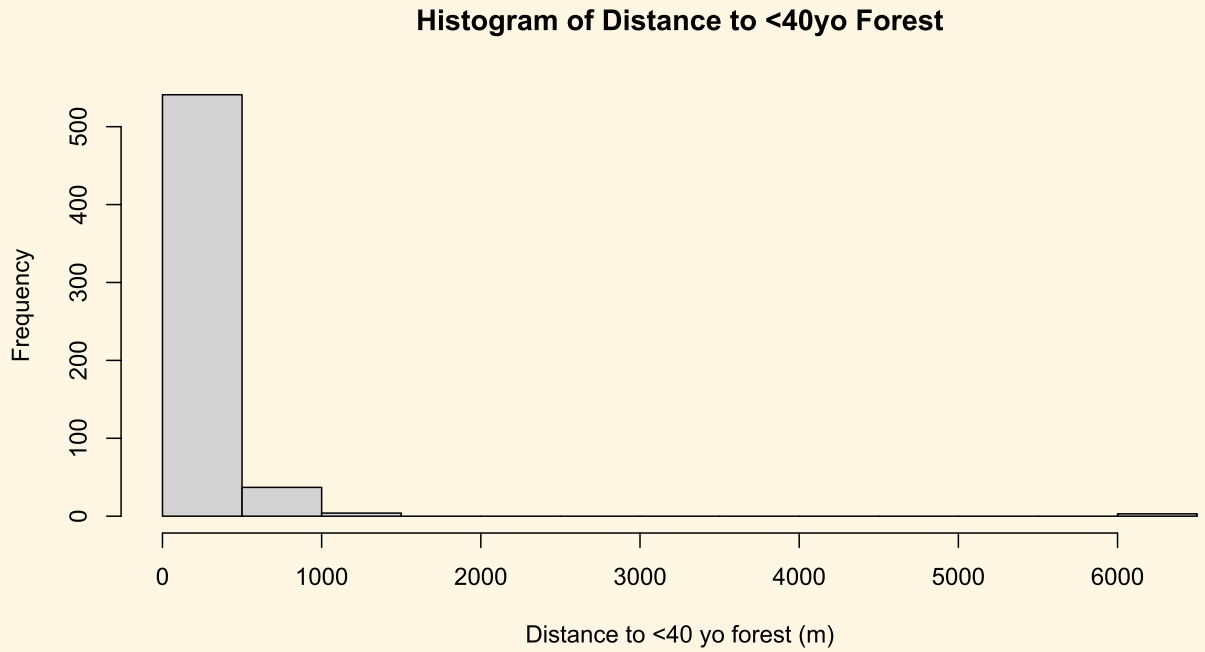
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.00 42.00 80.00 68.97 100.00 100.00 4
```



Distance to <40 yo forest

Note this includes all field visits, including dens with repeated visits.

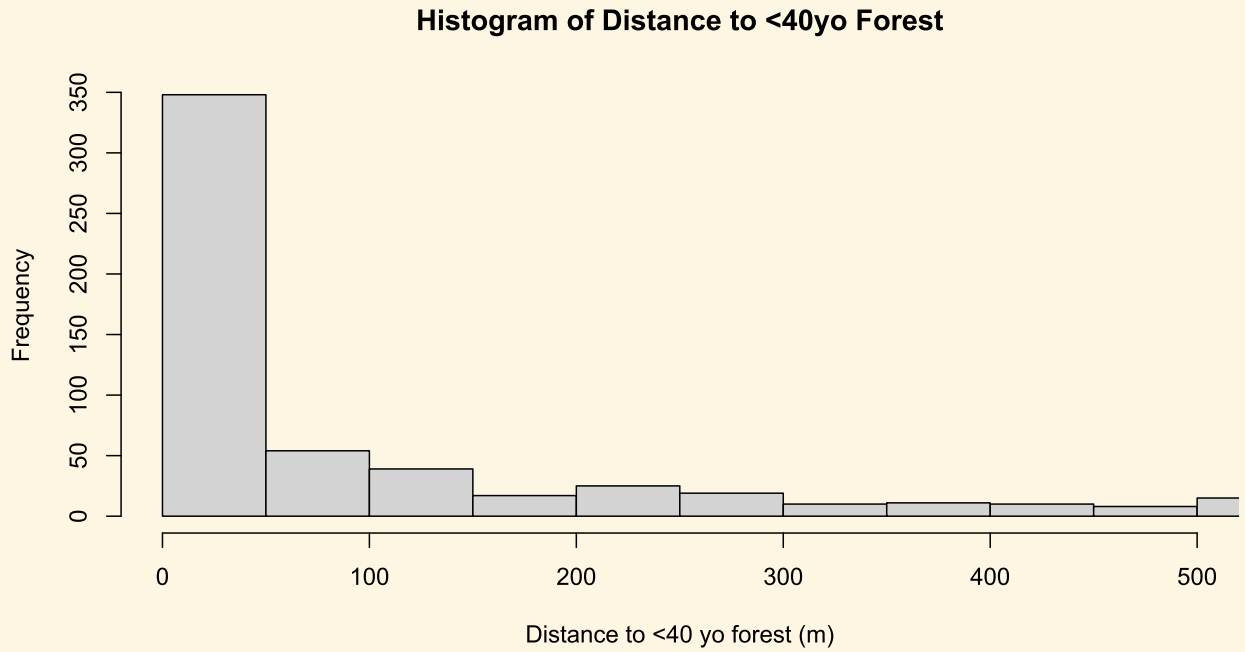
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.0 5.0 26.0 150.2 146.0 6300.0 5
```



Distance to <40 yo forest: Zoomed in to 0-500m

Majority of dens are <100 meters from <40 yo forest (cutblock edge).

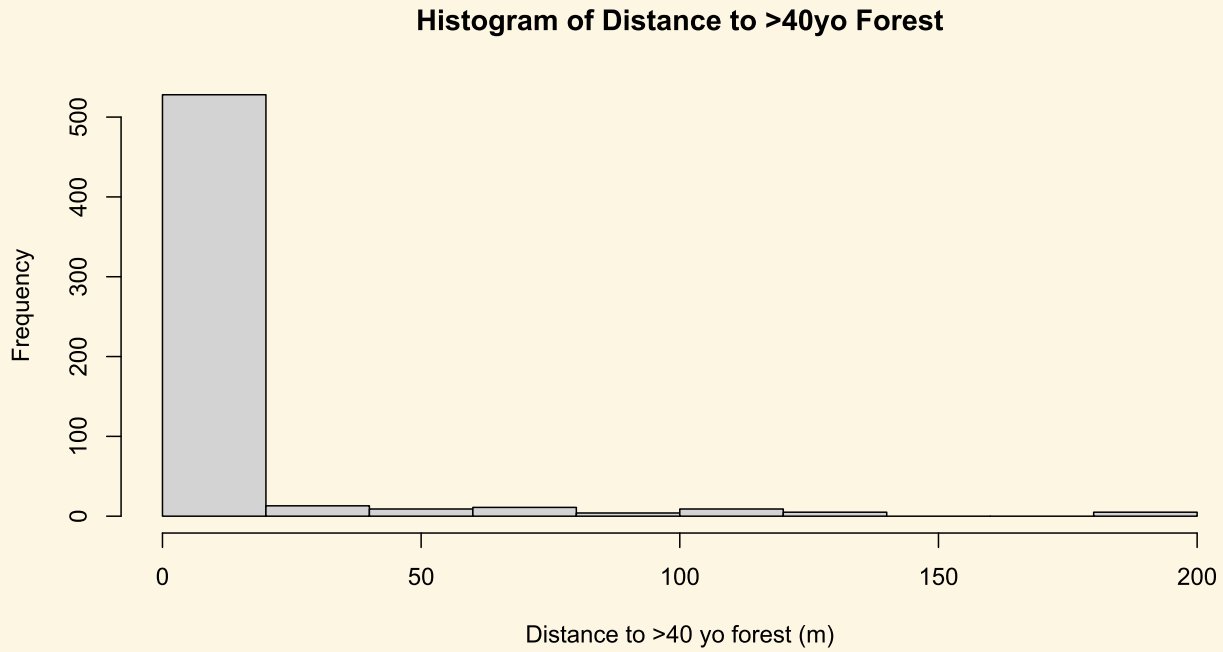
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.0 5.0 26.0 150.2 146.0 6300.0 5
```



Distance to >40 yo forest

Note this includes all field visits, including dens with repeated visits.

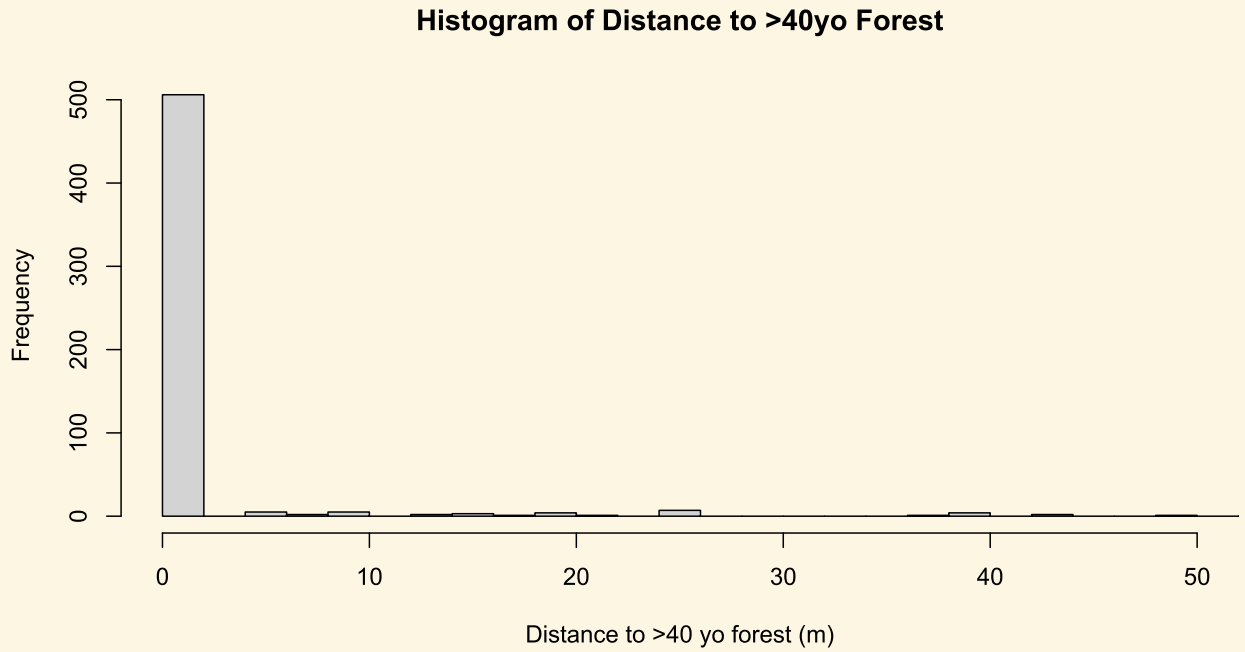
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.000 0.000 0.000 8.467 0.000 183.000 6
```



Distance to >40 yo forest: Zoomed in to 0-50m

Vast majority of dens are already *within* >40 yo forest.

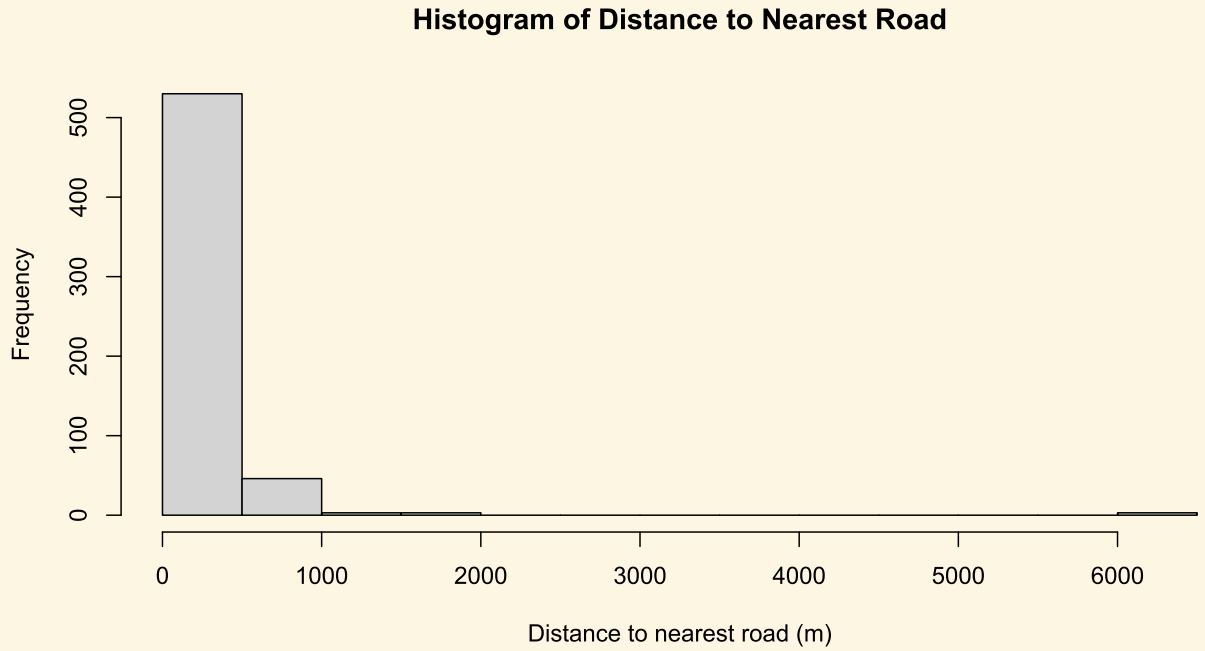
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.000 0.000 0.000 8.467 0.000 183.000 6
```



Distance to nearest road

Note this includes all field visits, including dens with repeated visits.

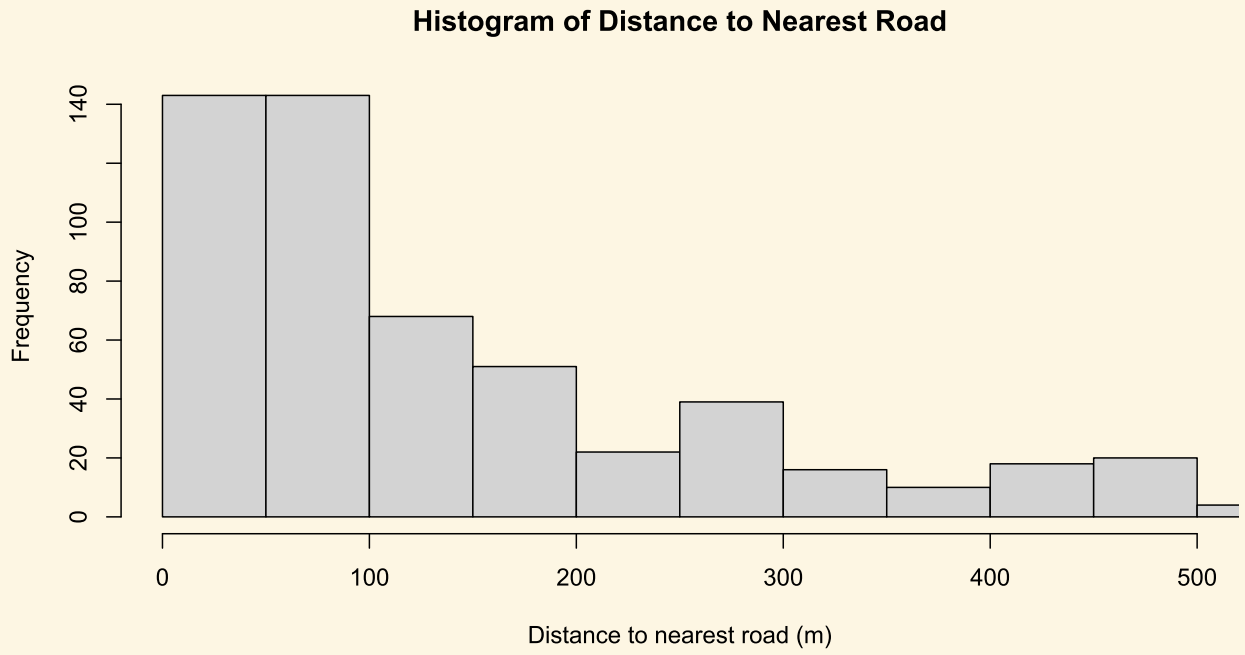
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 5.0 55.0 107.0 226.6 281.0 6300.0 5
```



Distance to nearest road: Zoomed in to 0-500m

Distribution is skewed towards 0, but less so than distance to cutblock edge/ mature growth.

```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 5.0 55.0 107.0 226.6 281.0 6300.0 5
```



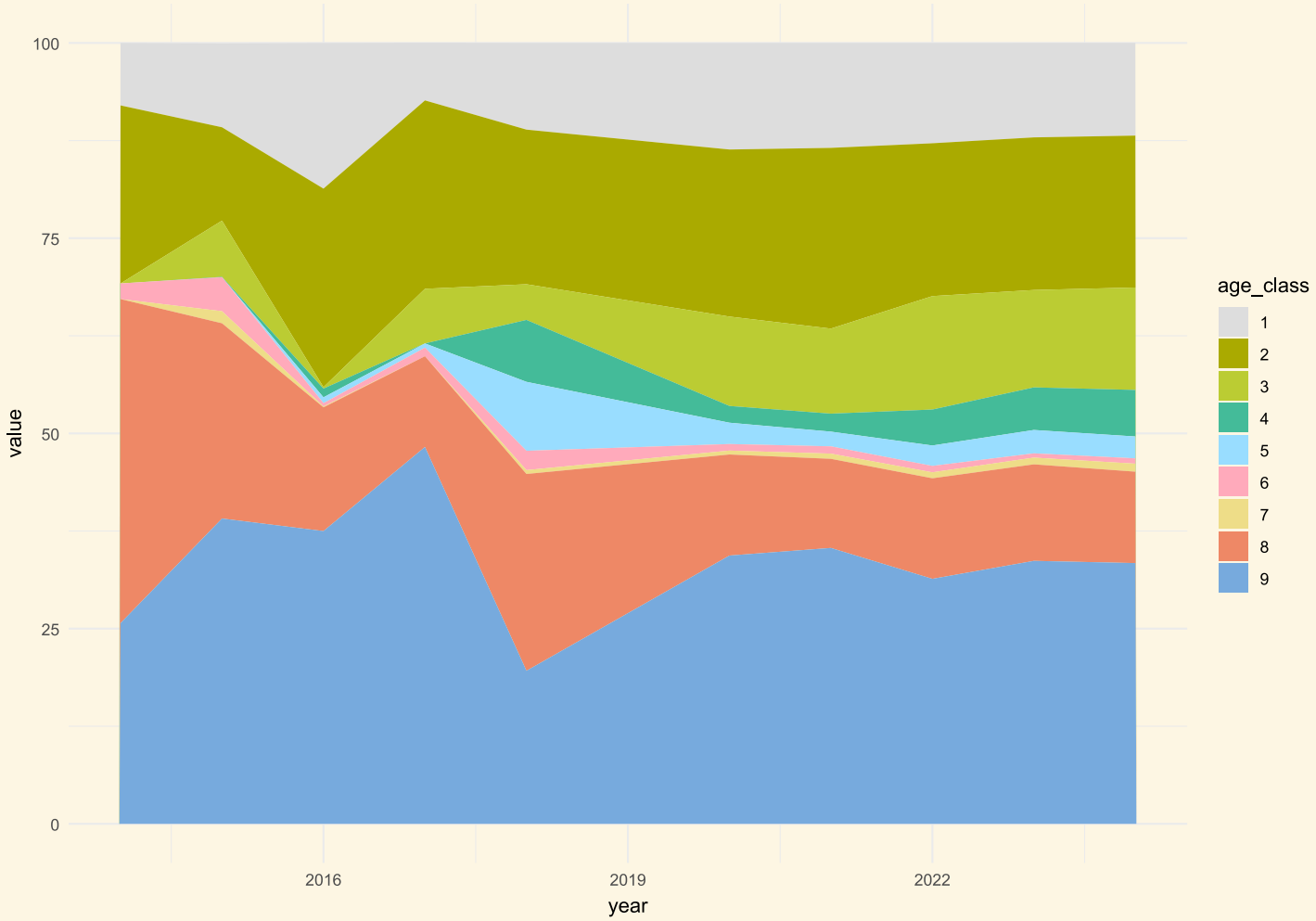
Proportion age class within 1.5 km

Note this includes all field visits, including dens with repeated visits

Stand Age Class	Percentage
age_class_1	13
age_class_2	20
age_class_3	12
age_class_4	5
age_class_5	3
age_class_6	1
age_class_7	1
age_class_8	12
age_class_9	34

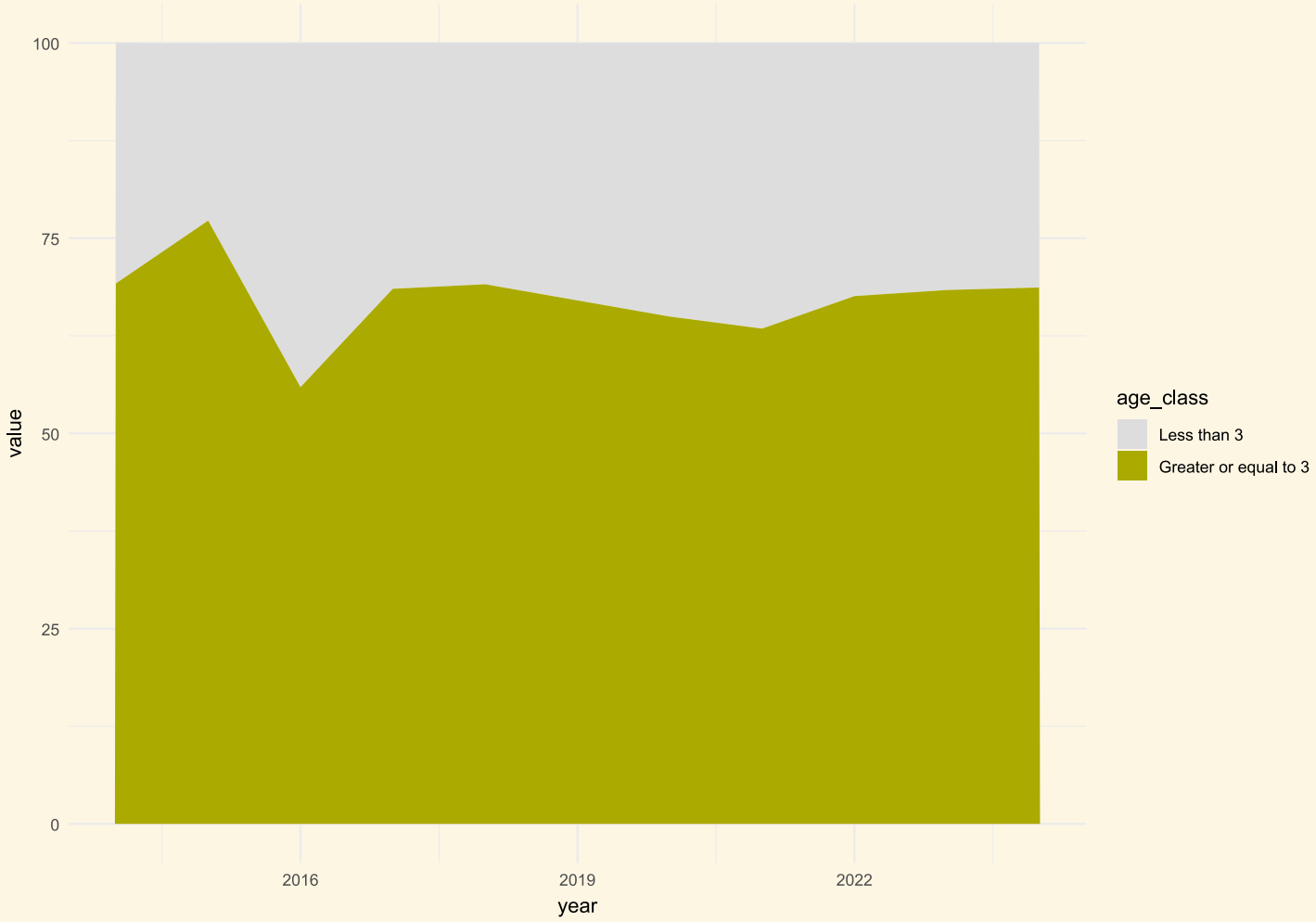
Proportion age class within 1.5 km

Note this includes all field visits, including dens with repeated visits



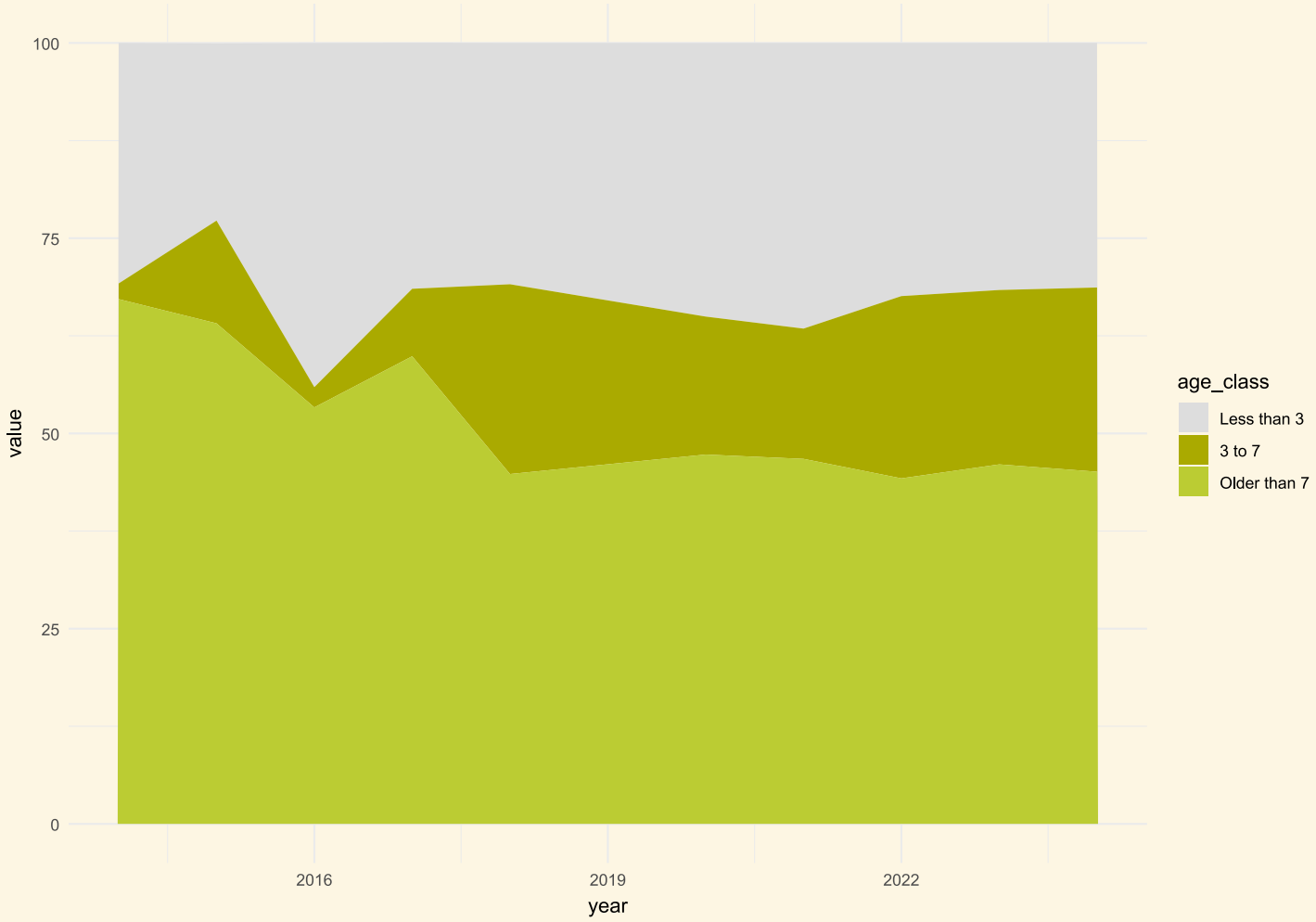
Proportion age class within 1.5 km

Note this includes all field visits, including dens with repeated visits



Proportion age class within 1.5 km

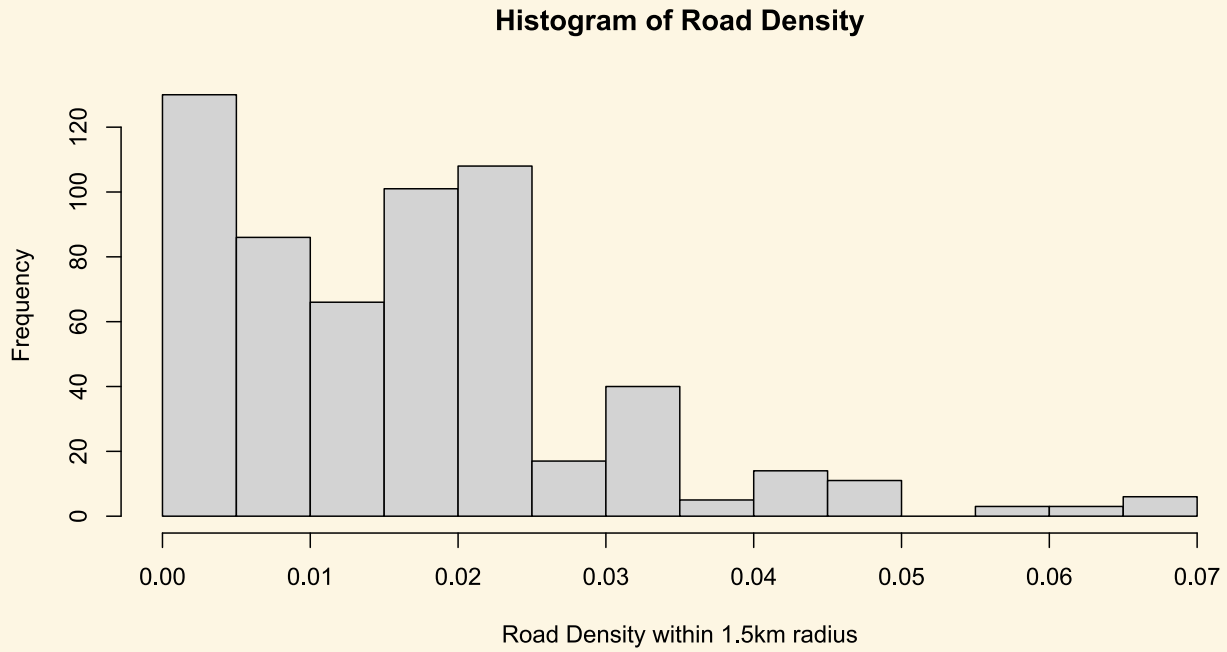
Note this includes all field visits, including dens with repeated visits



Road density within 1.5 km

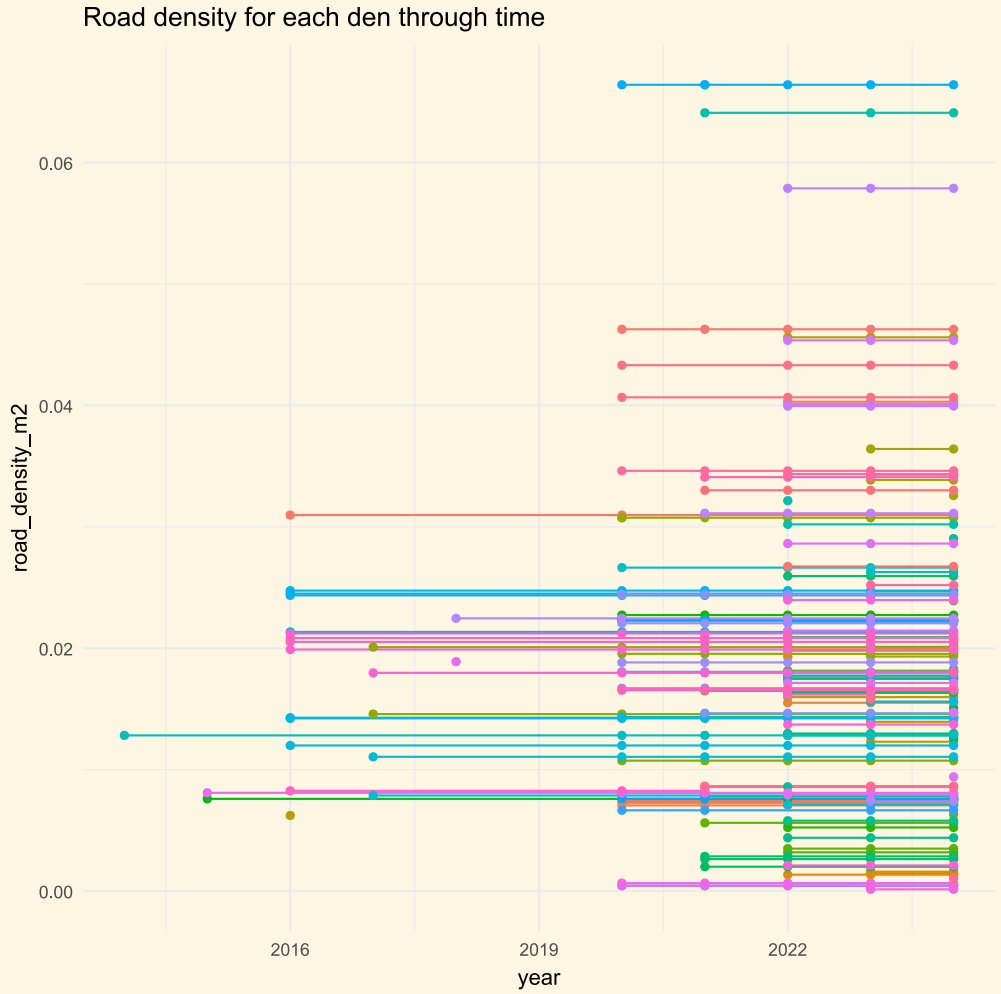
Note this includes all field visits, including dens with repeated visits.

```
## Min. 1st Qu. Median Mean 3rd Qu. Max.
## 0.000000 0.007054 0.016335 0.016250 0.022306 0.066399
```



Road density within 1.5 km

It doesn't change much through time... (this will be a theme)



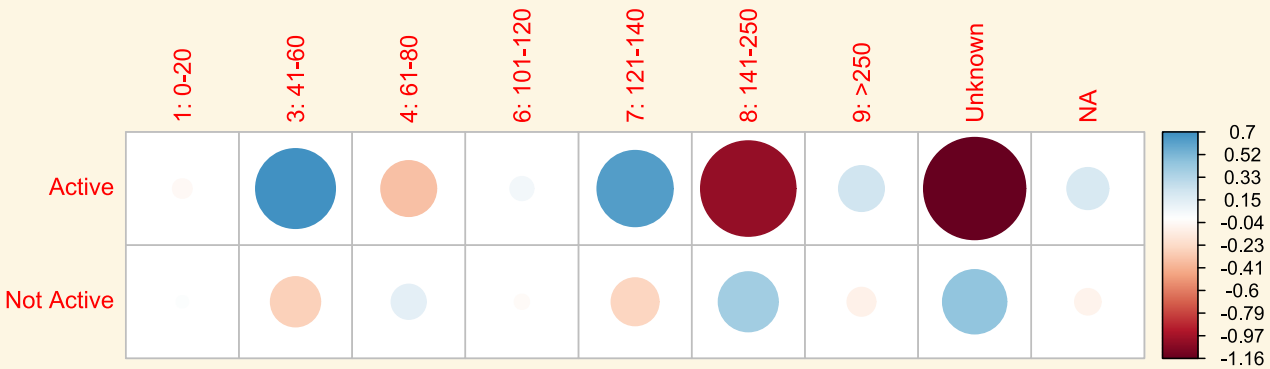
Forestry vs. Den Status

Forestry vs. Den Status

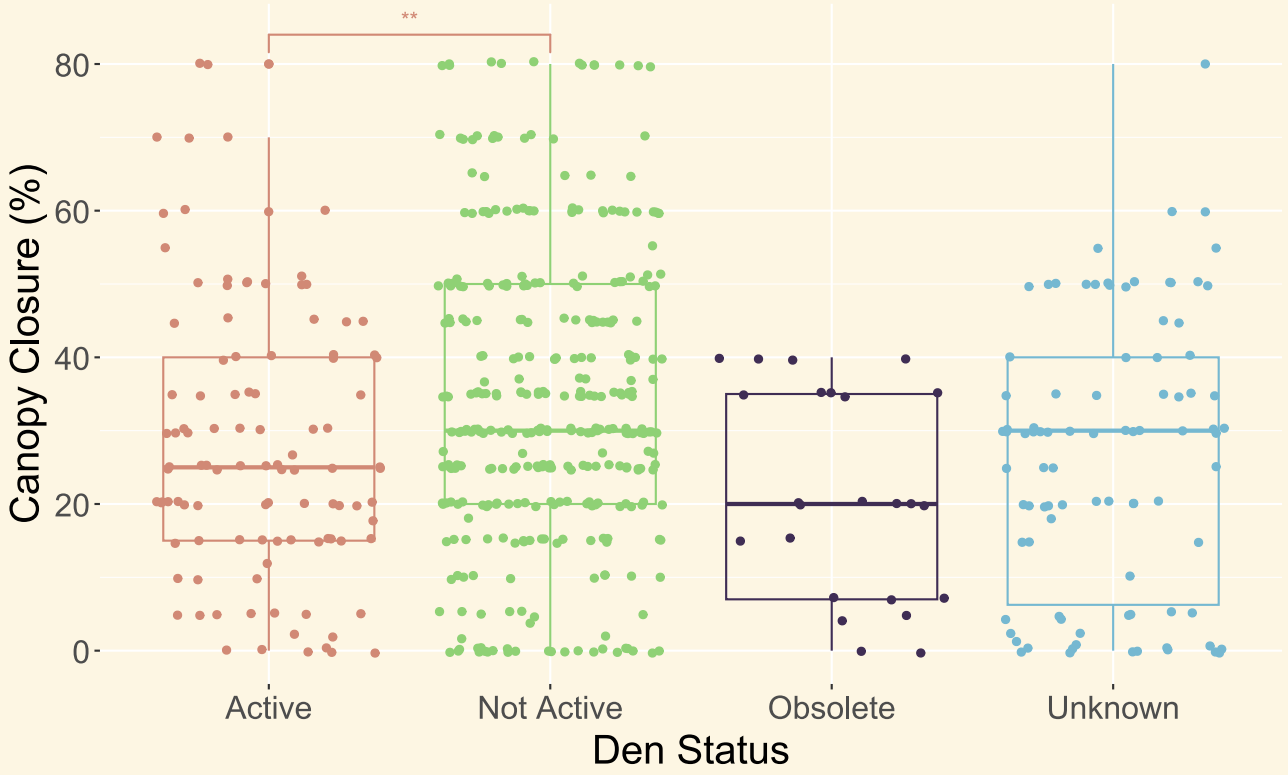
Now, we need to do a bit of data wrangling. In theory, the den status of **the current year** is influenced by the forestry data **from the year before**. So, we match the den status with last year's forestry data from our field visits. In doing so, this cuts our dataset own to 363 records.

With the exception of age class and canopy closure, all subsequent plots show den status of year *N* versus forestry data from year *N - 1*. Age class and canopy closure were only measured once in the study (at the first den visit).

Den Status vs Age Class

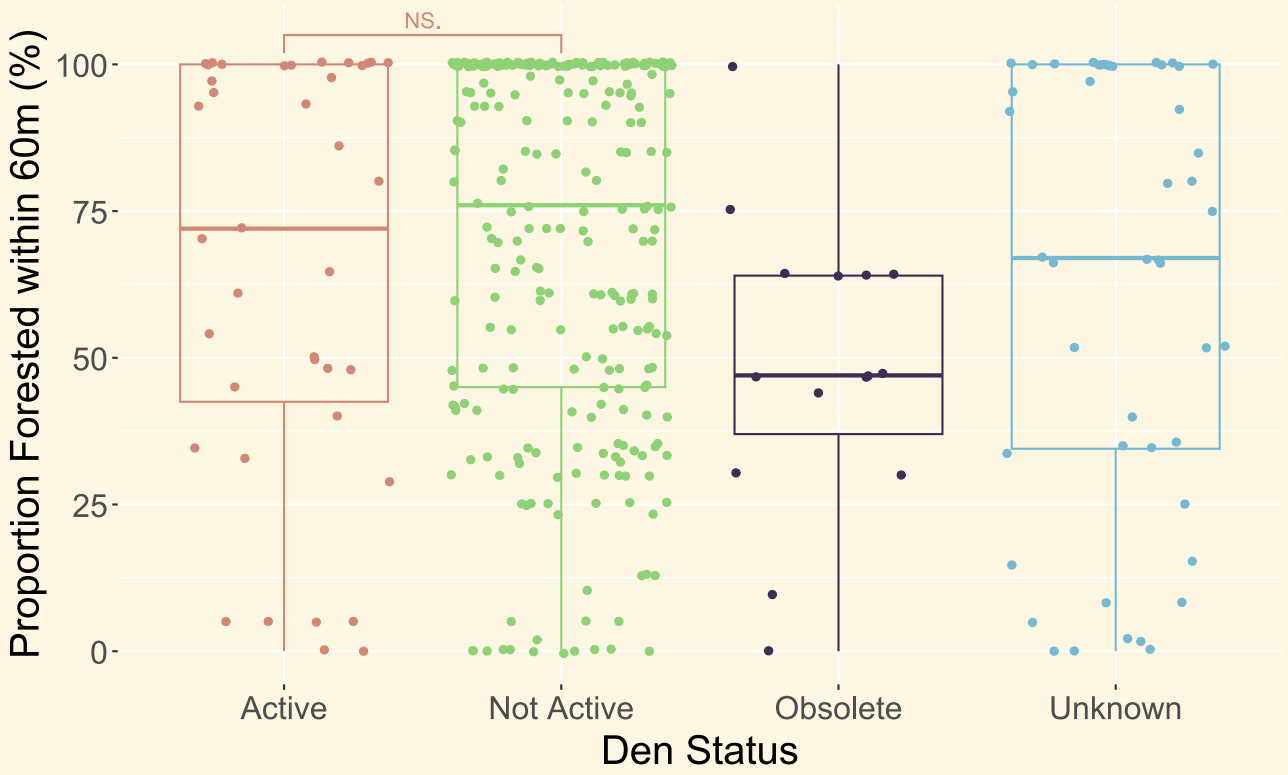


Den Status vs Canopy Closure

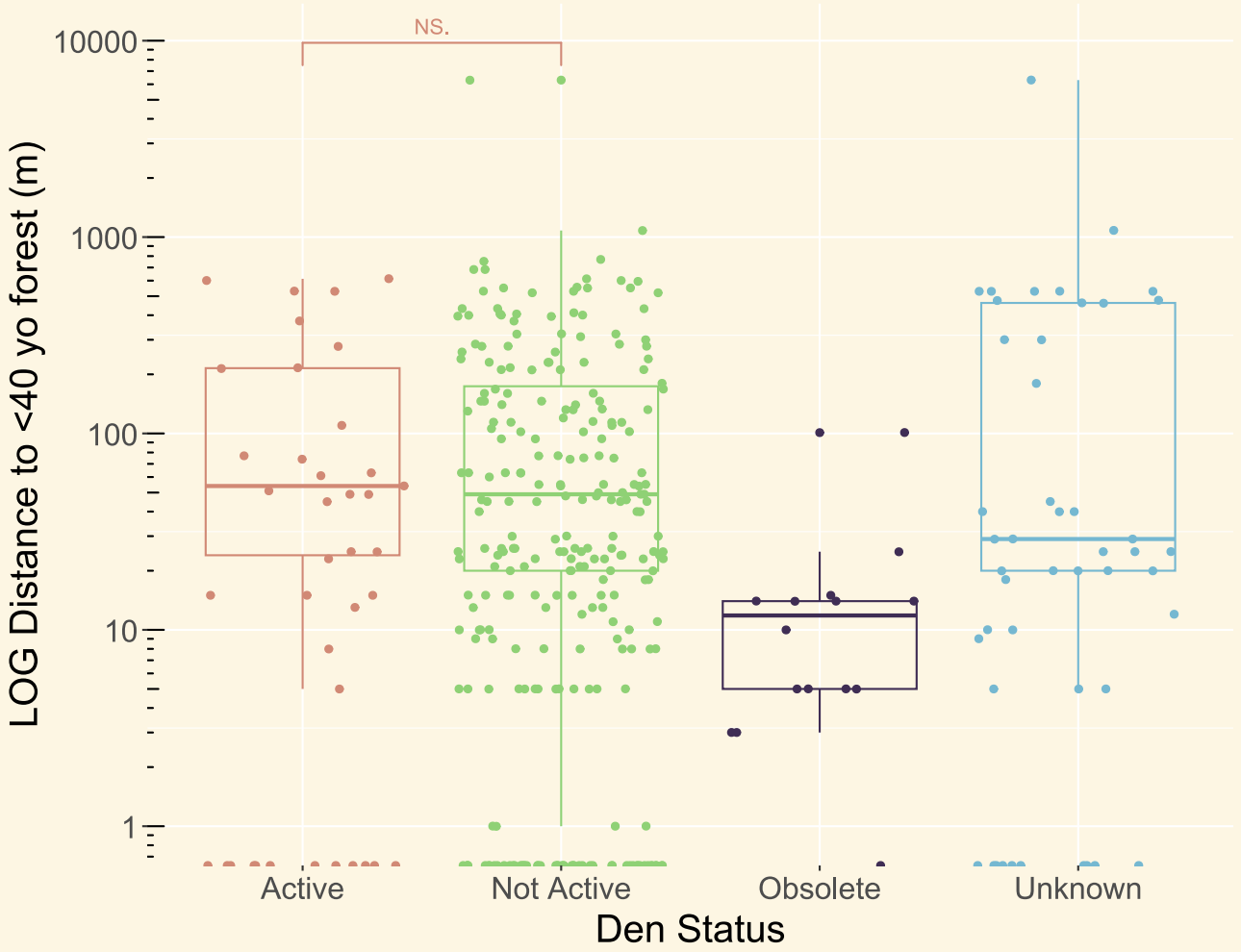


Den Status vs Patch Type

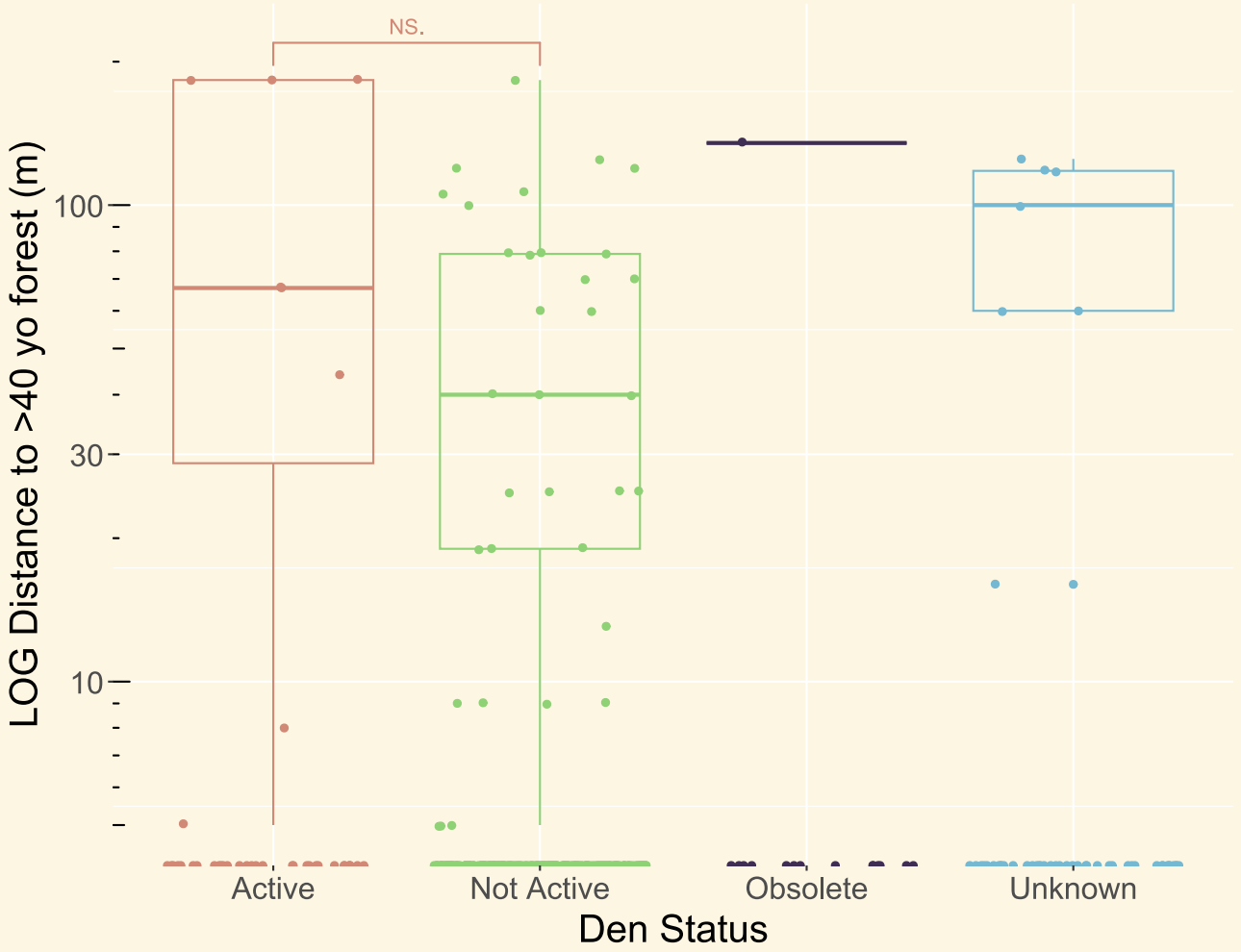
Den Status vs Proportion Forested within 60m



Den Status vs Distance to <40 yo Forest



Den Status vs Distance to >40 yo Forest



Den Status vs Distance to >40 yo Forest

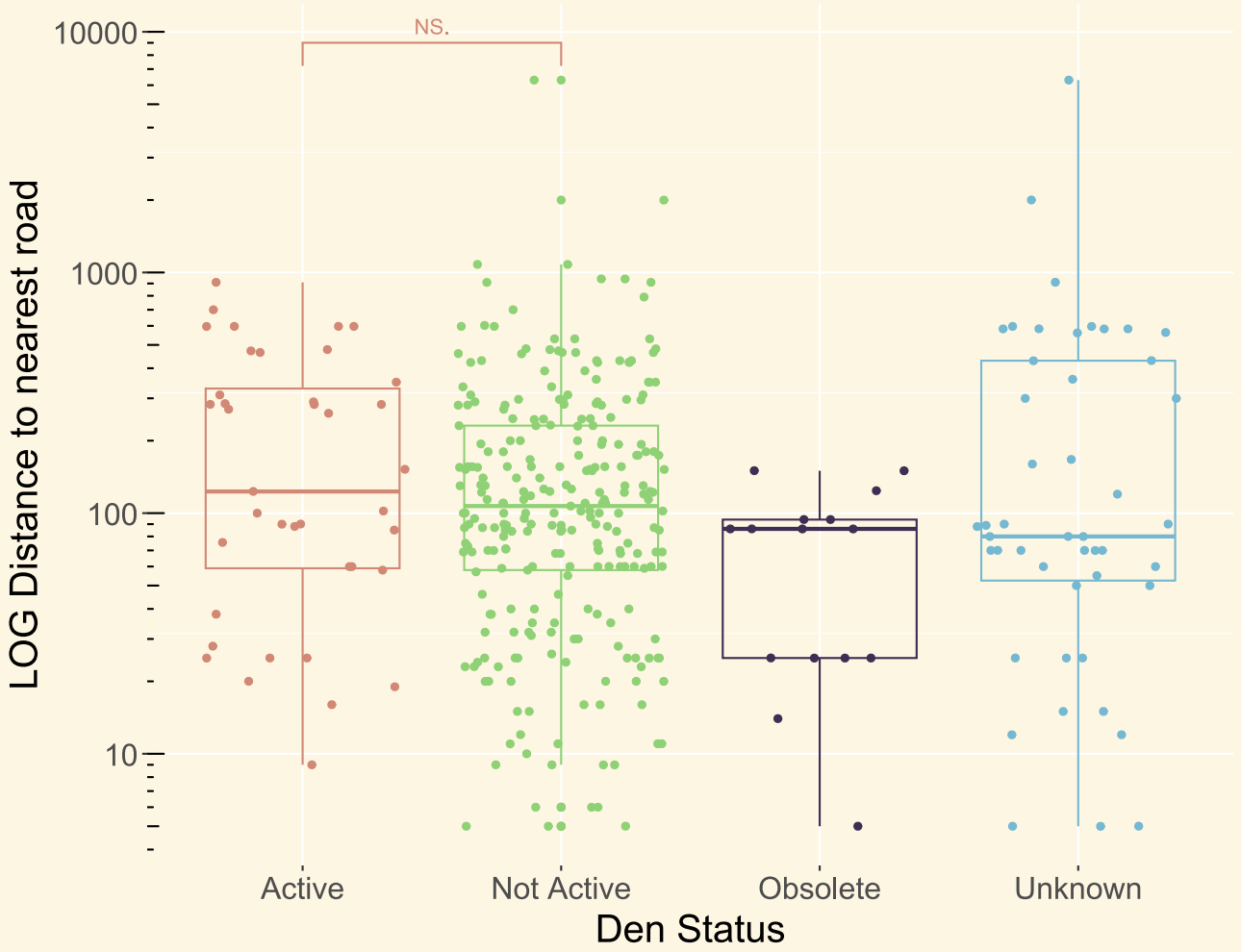
What are those 6 data points where distance to mature forest is >30 meters?

Turns out it's all from 3 distinct dens:

Show 8 entries Search:

	den_id	sample_id	landscape_unit	x_den_data_source	struct_stage	age_class	c
32	BON_WestMain_10	BON_WestMain_10_20240911	Bonanza				
123	LOW_TlakwaCreek_1	LOW_TlakwaCreek_1_20230926	Lower Nimpkish	H Davis telemetry	3b: Tall shrub	1: 0-20	

Den Status vs Distance to Nearest Road

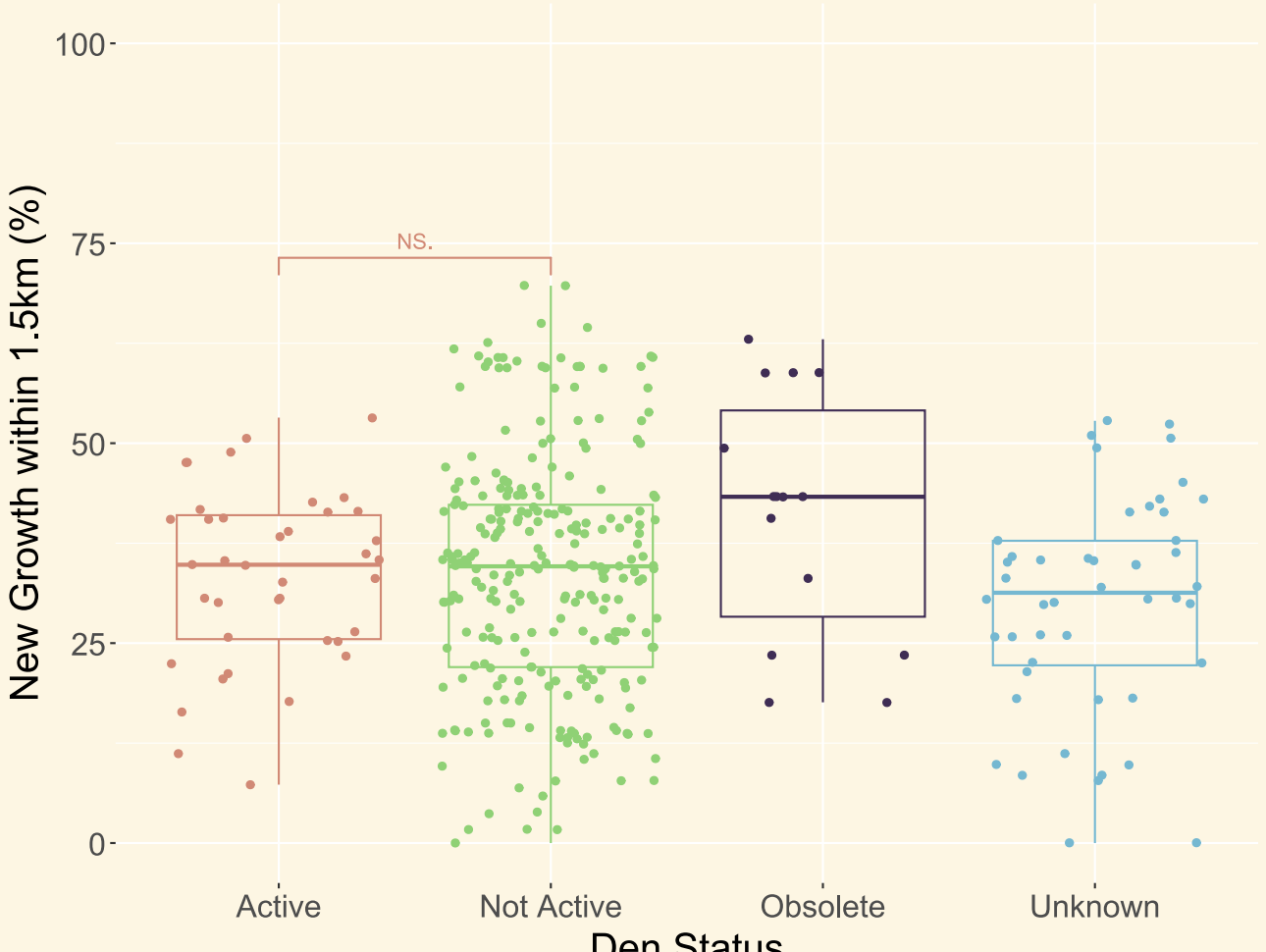


Den Status vs Proportion Old Growth

'Old growth' being % coverage of age class 8 or 9 within 1.5km of the den.

Den Status vs Proportion New Growth

'New growth' being % coverage of age class 1 or 2 within 1.5km of the den.

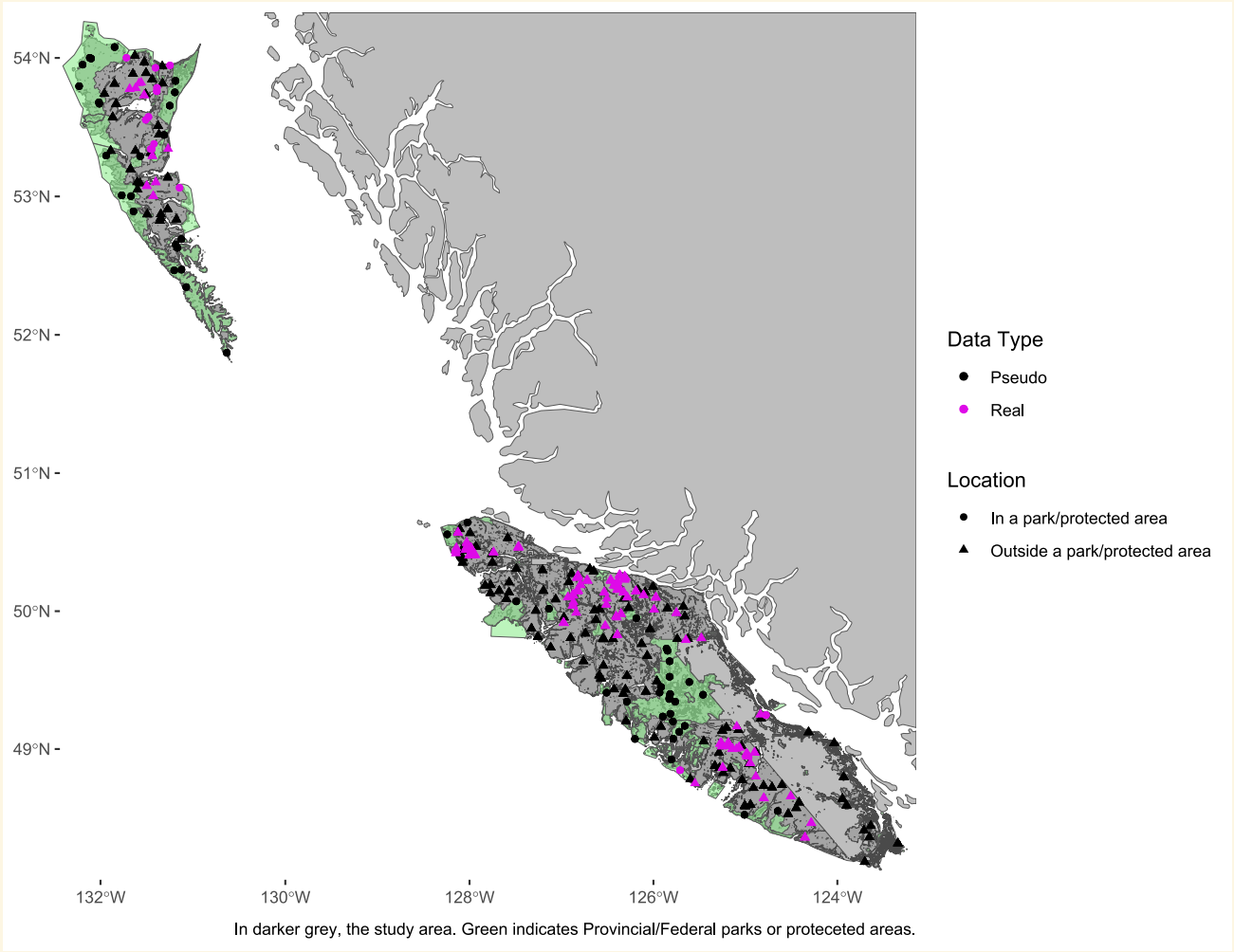


How well are we sampling the landscape?

How well are we sampling the landscape?

The next set of slides will compare points randomly sampled across the landscape versus our dens. Compared to just randomly dropping pins on a map of Vancouver Island and Haida Gwaii, how well are we sampling the landscape with our sample of dens?

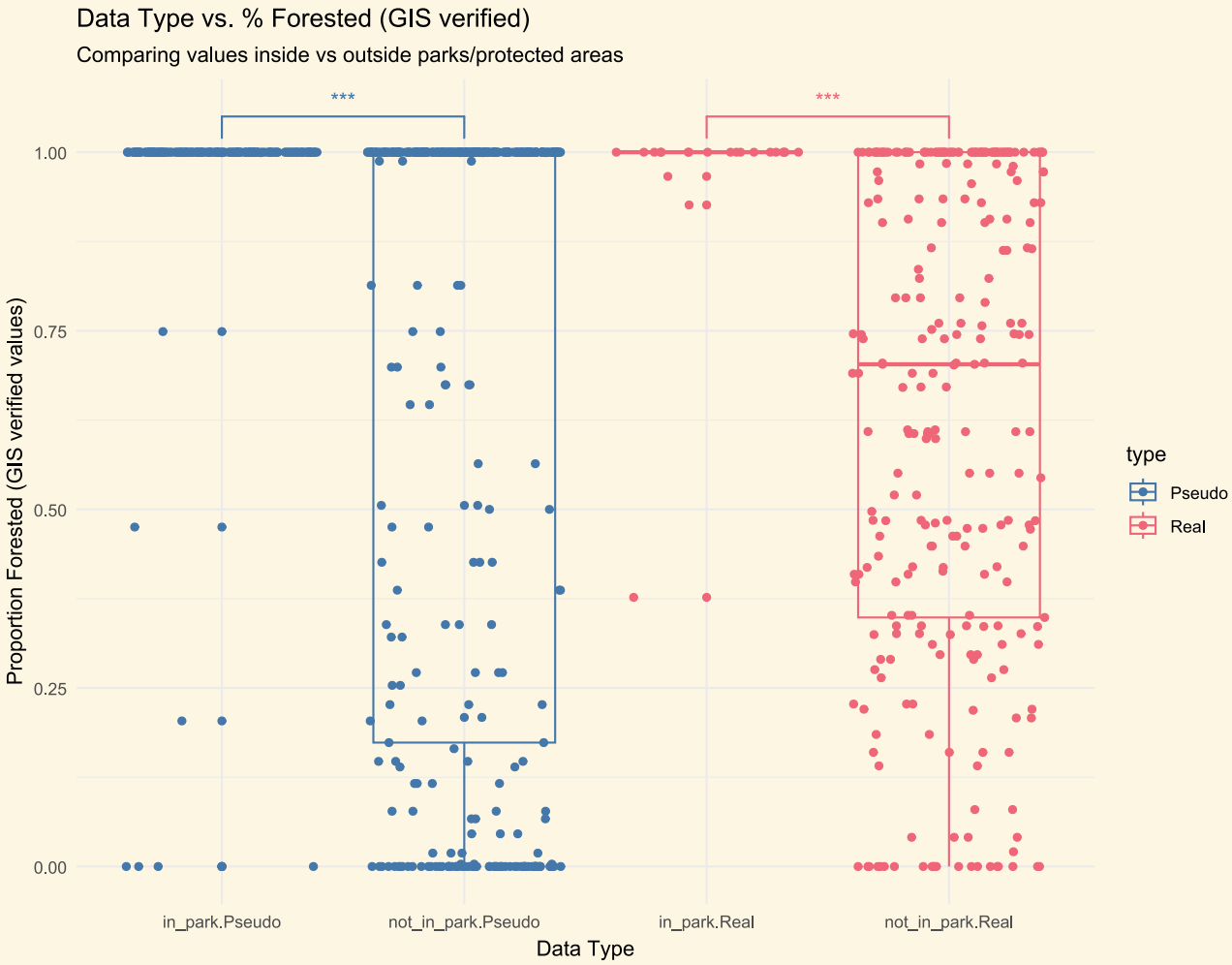
30% of the randomly sampled 'pseudo dens' fall within park lands or protected areas, in contrast to only 9% of the dens sampled in this study.



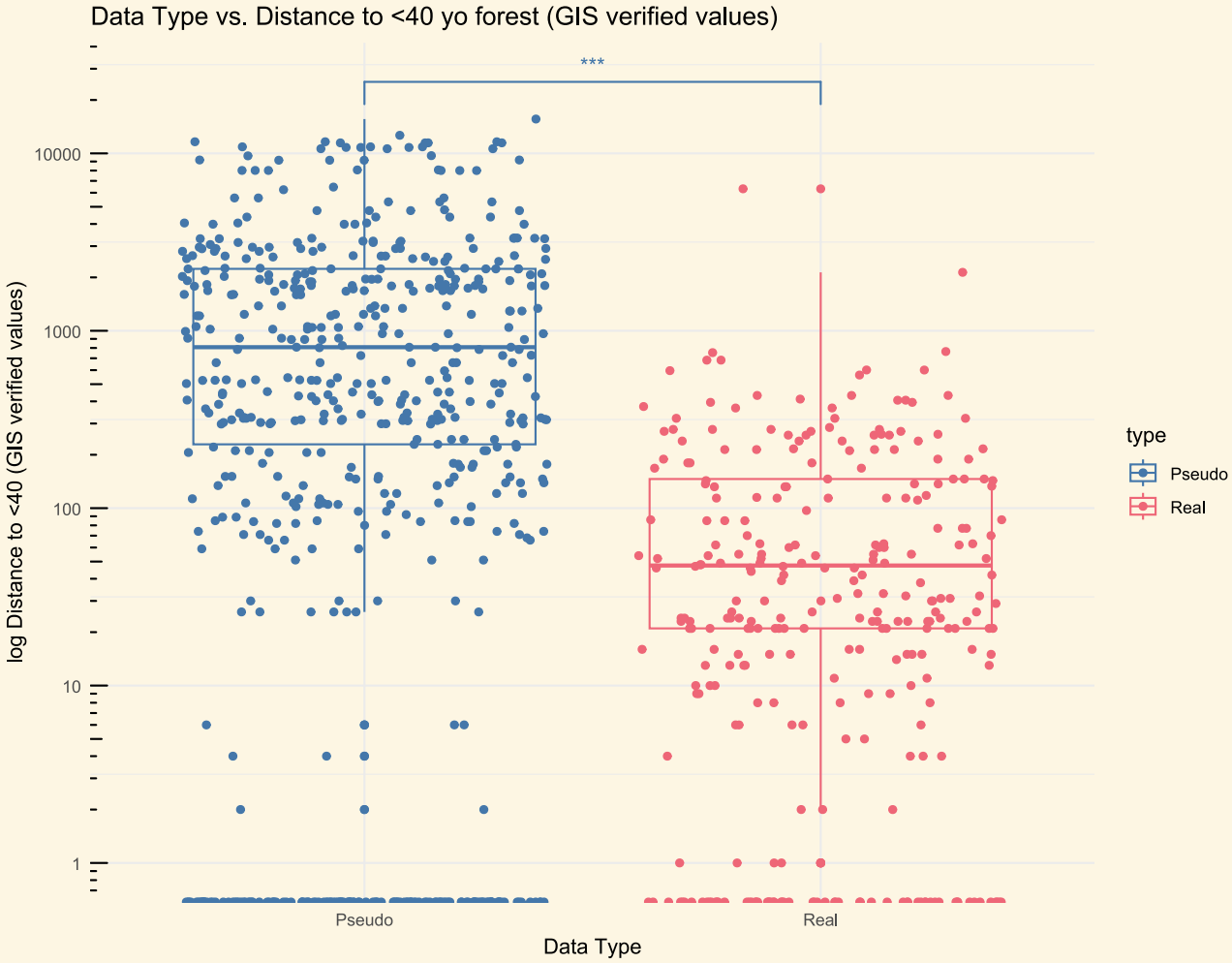
In darker grey, the study area. Green indicates Provincial/Federal parks or proteceted areas.

Comparing pseudo data to real data

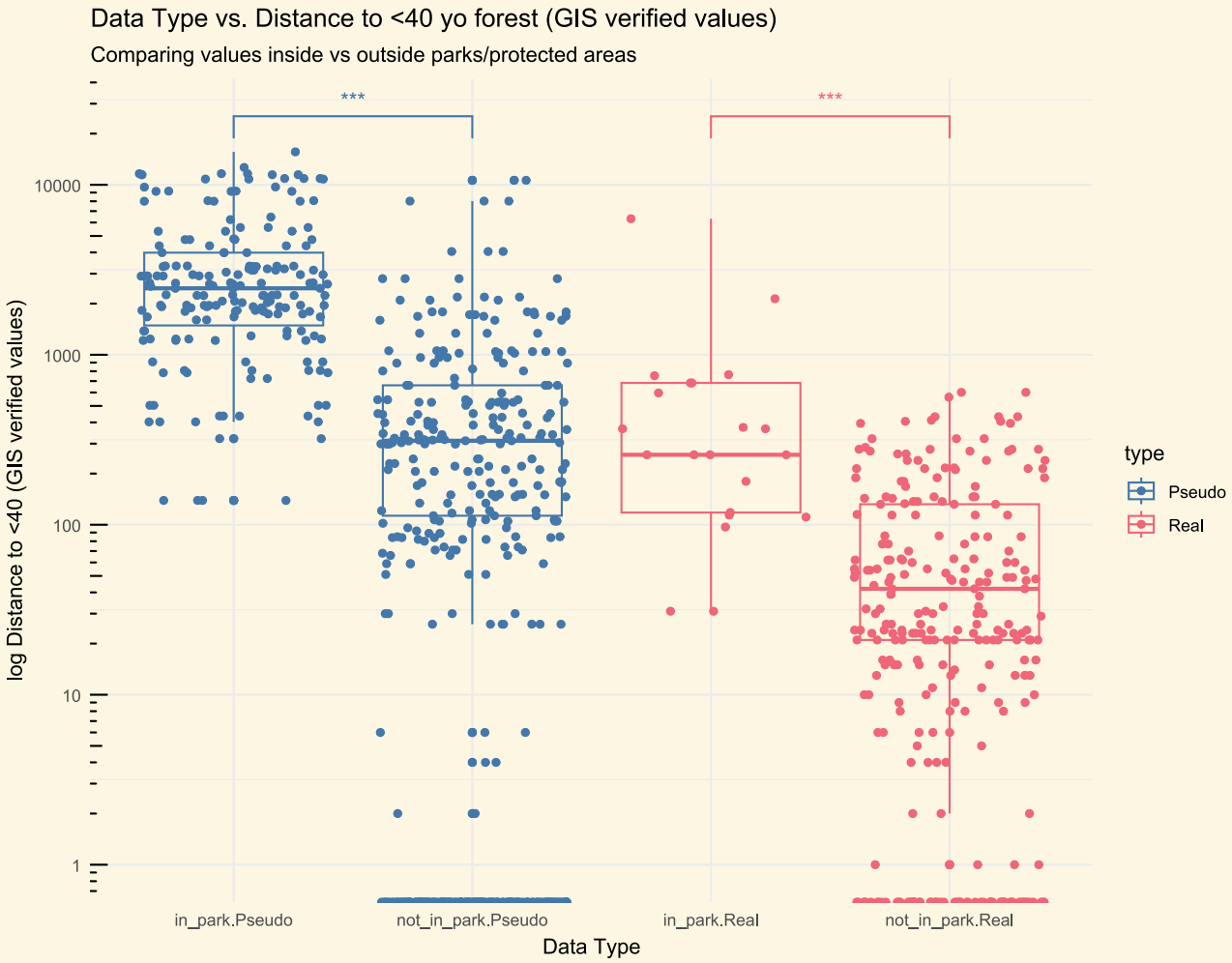
Comparing pseudo data to real data



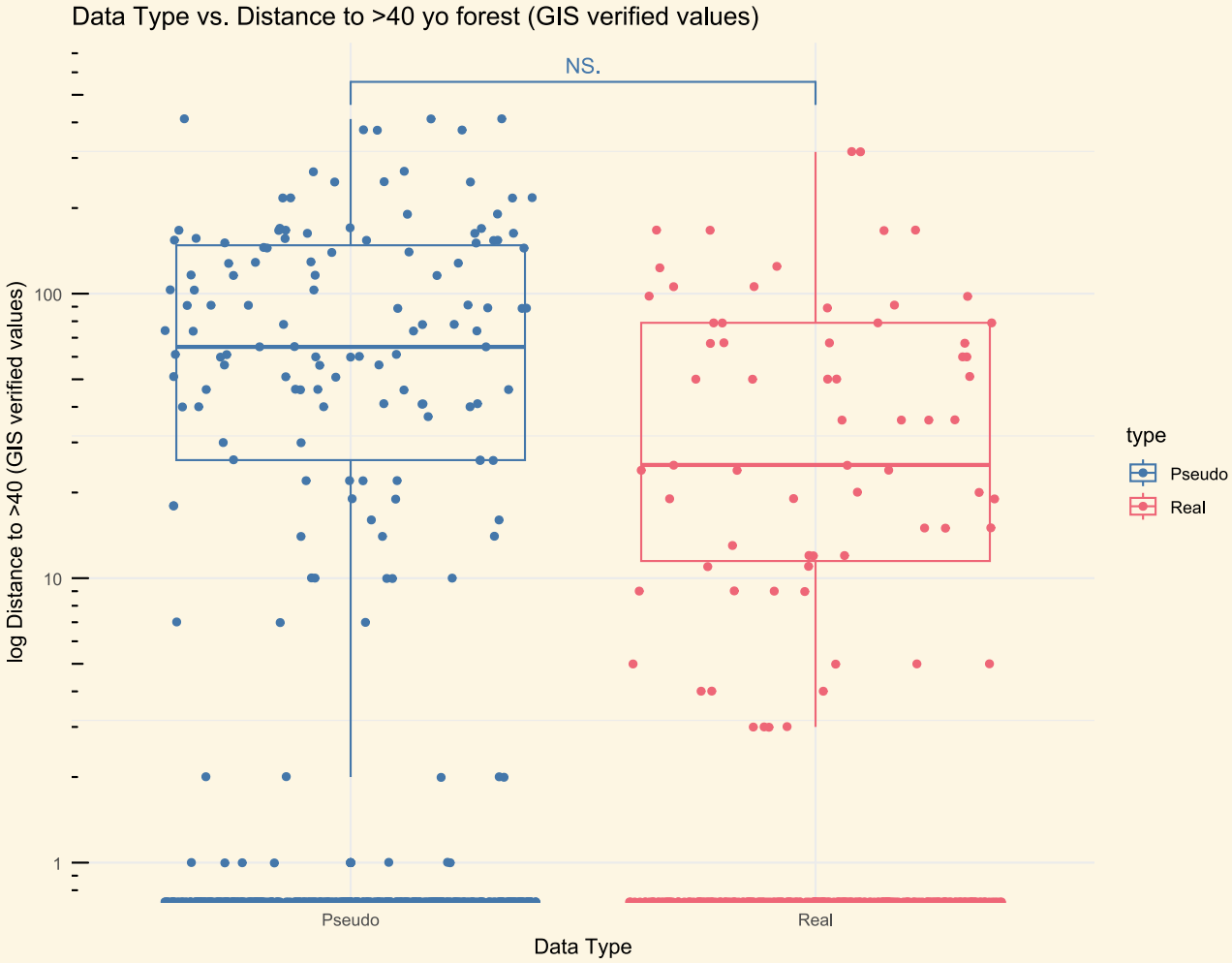
Comparing pseudo data to real data



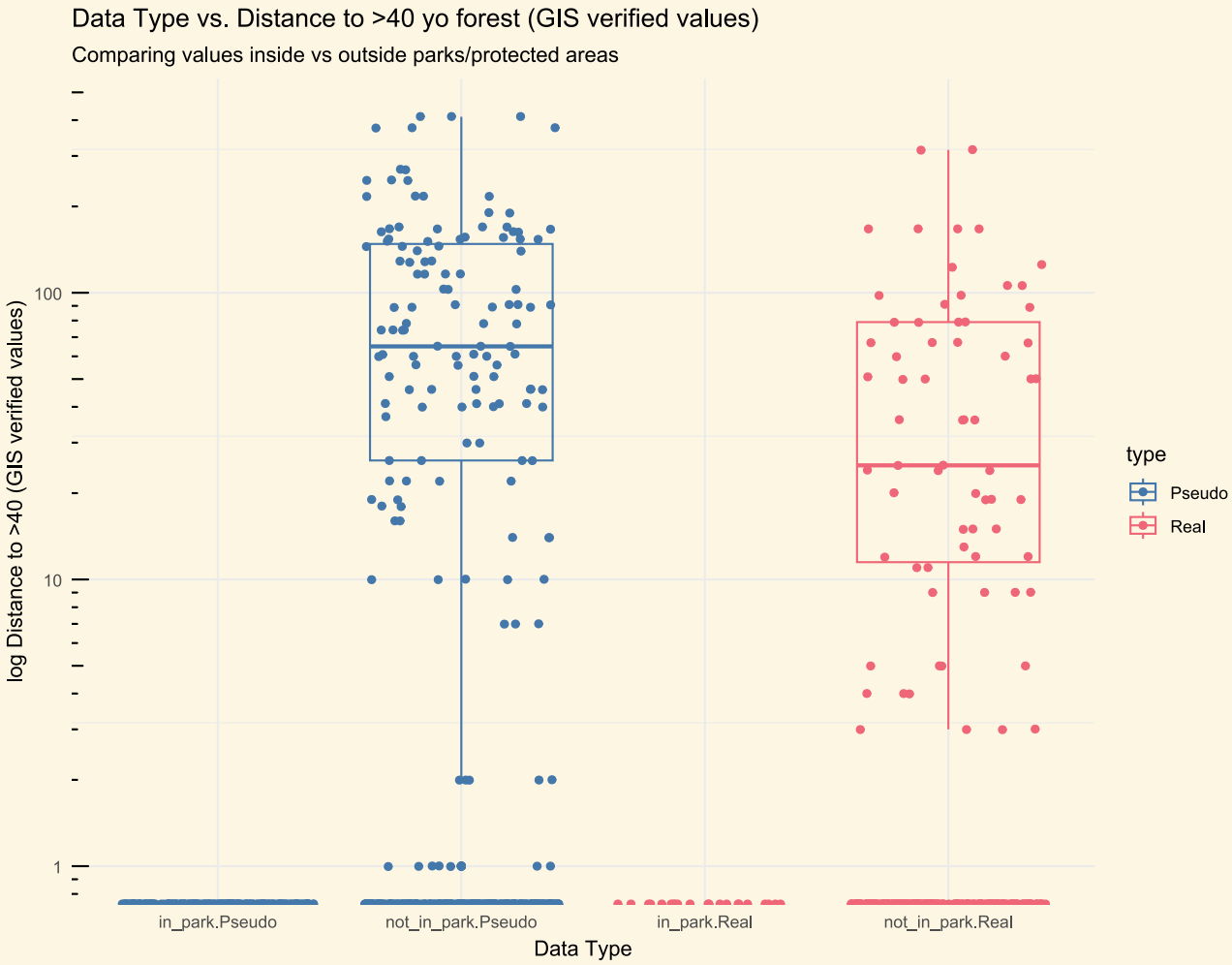
Comparing pseudo data to real data



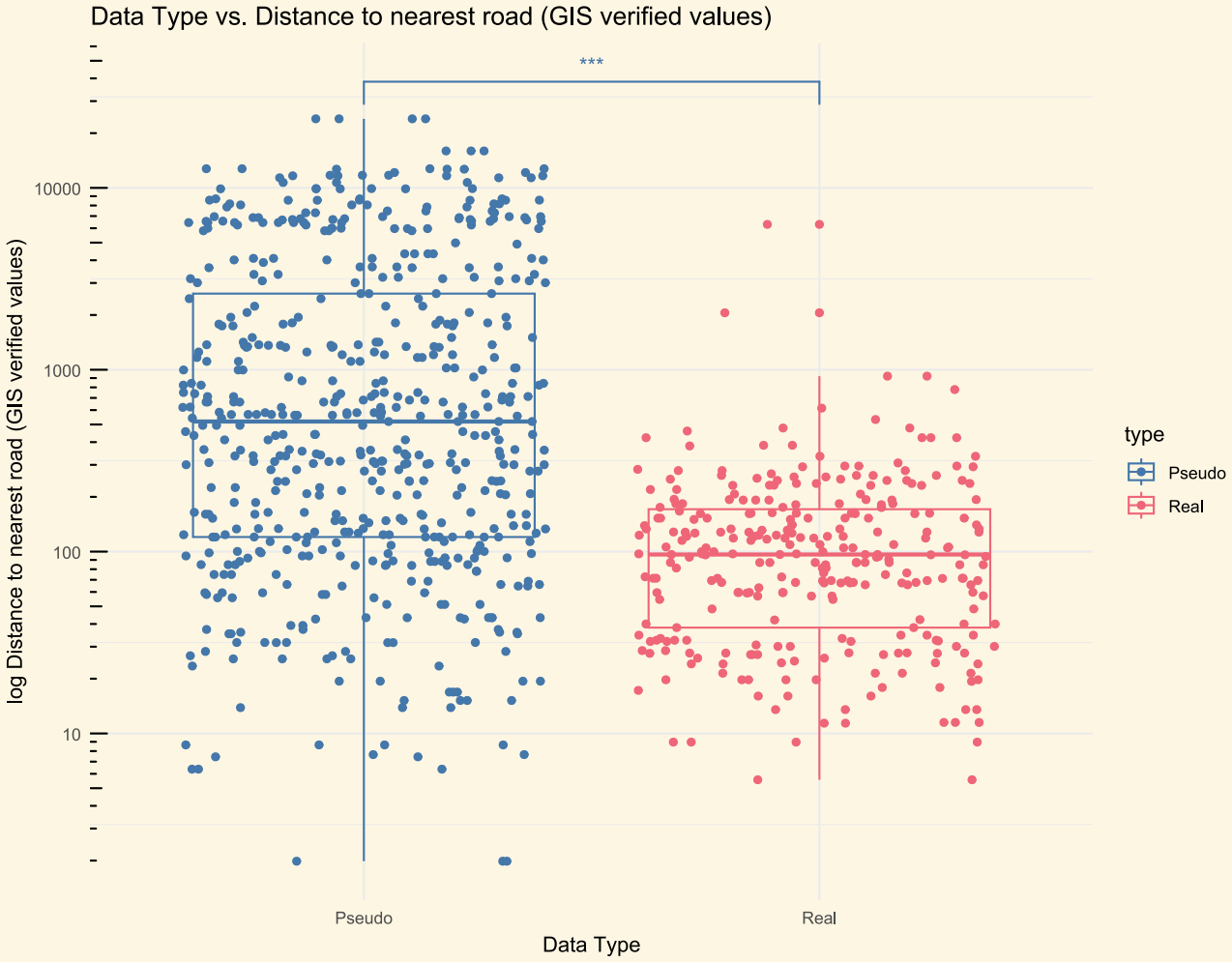
Comparing pseudo data to real data



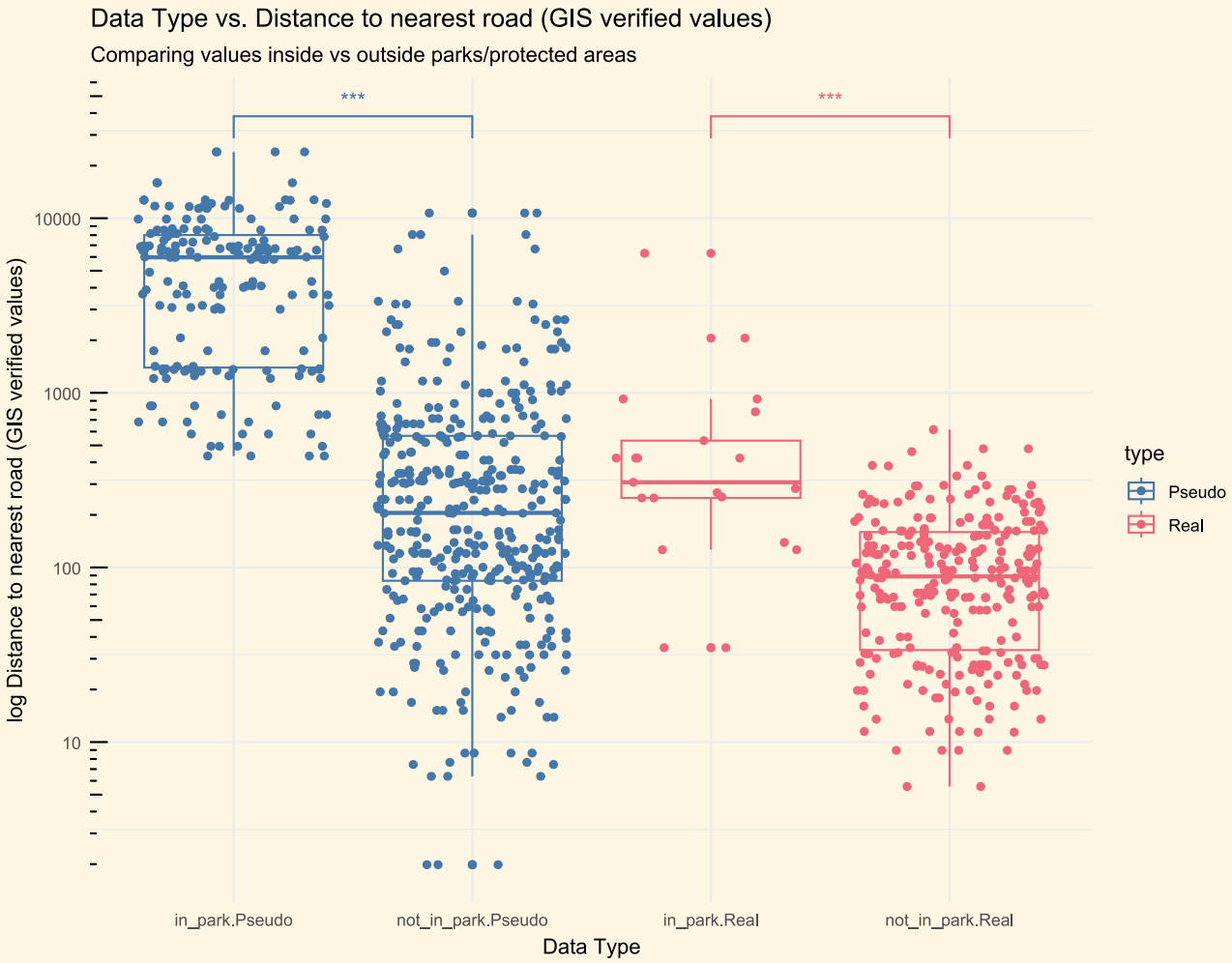
Comparing pseudo data to real data



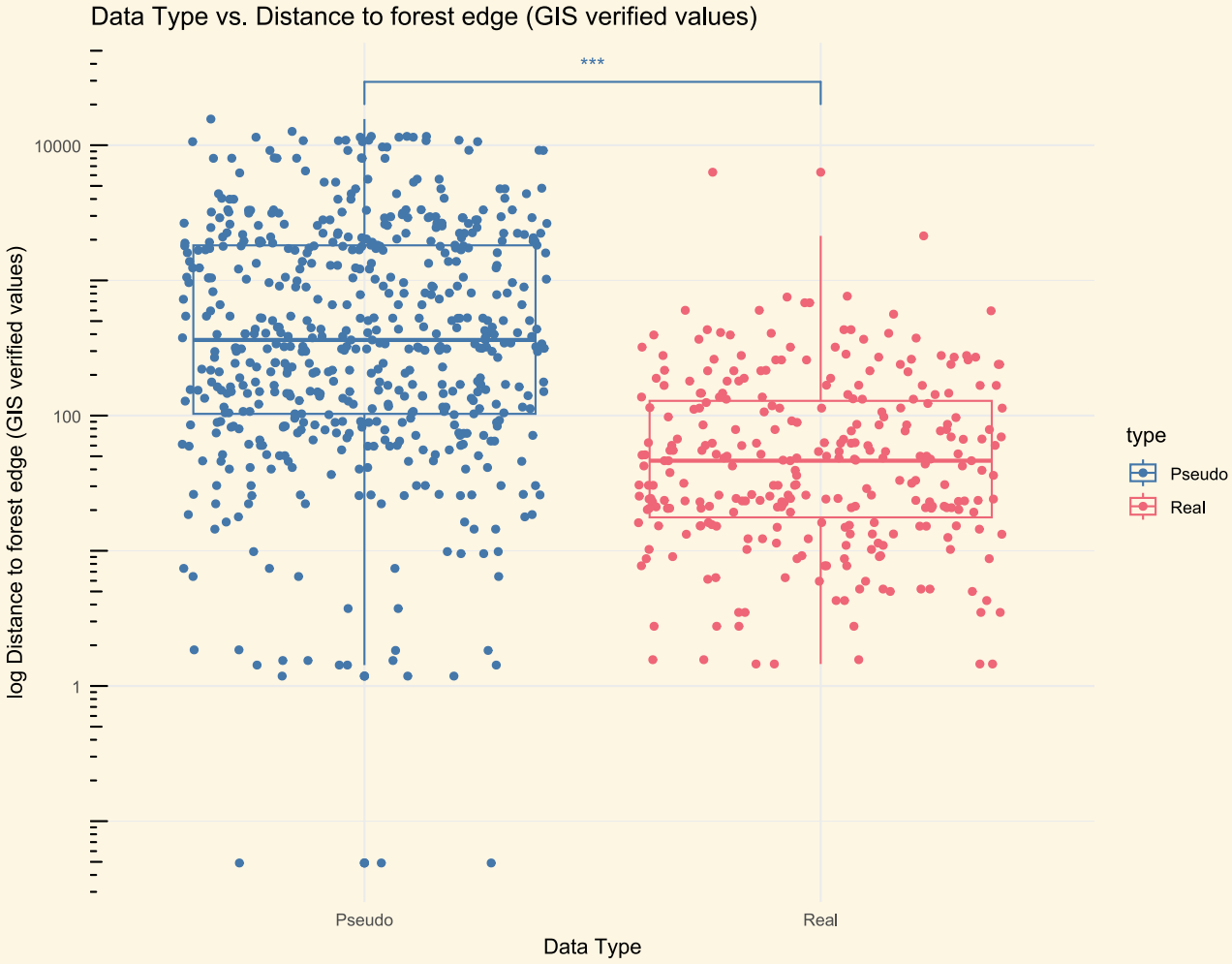
Comparing pseudo data to real data



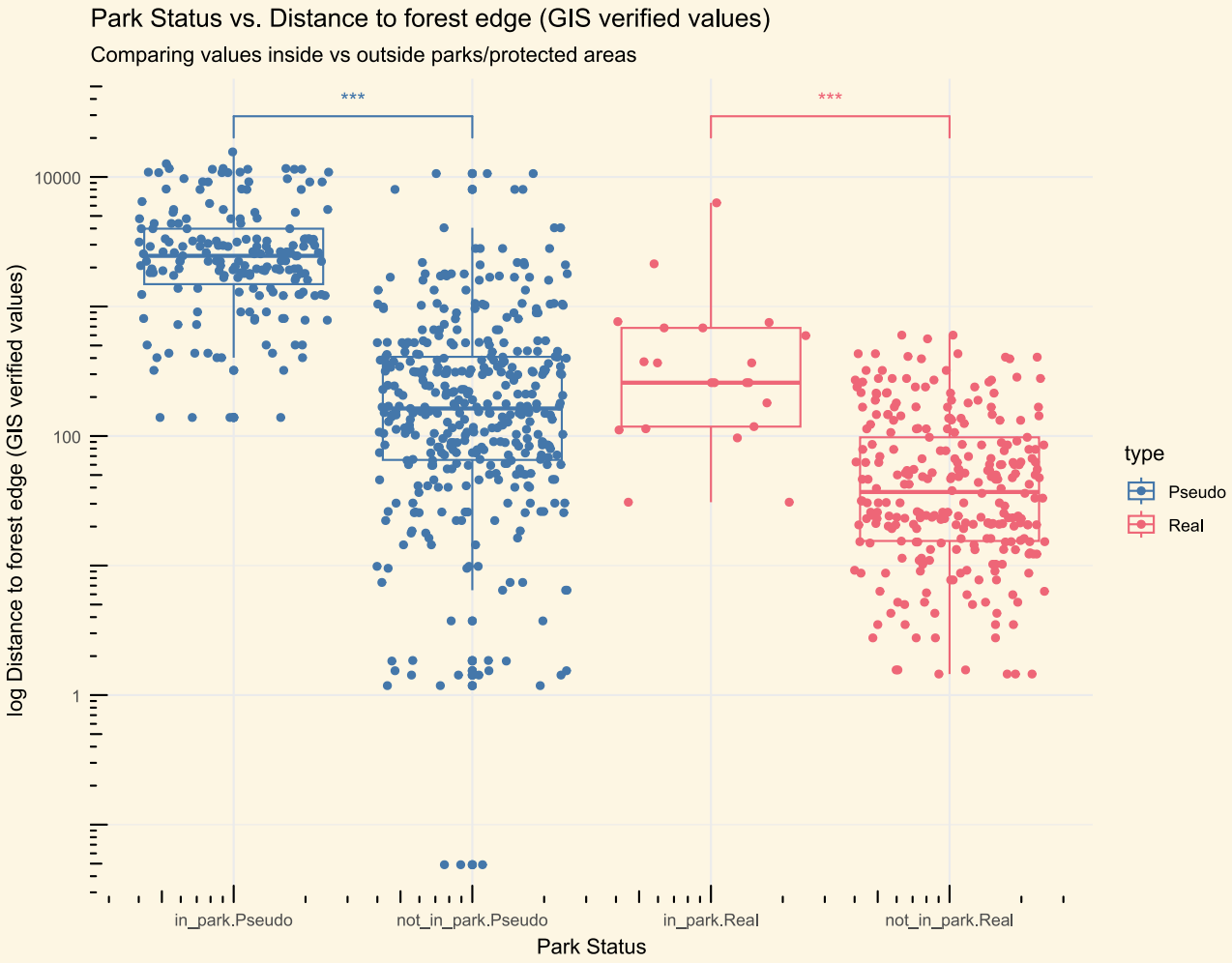
Comparing pseudo data to real data



Comparing pseudo data to real data

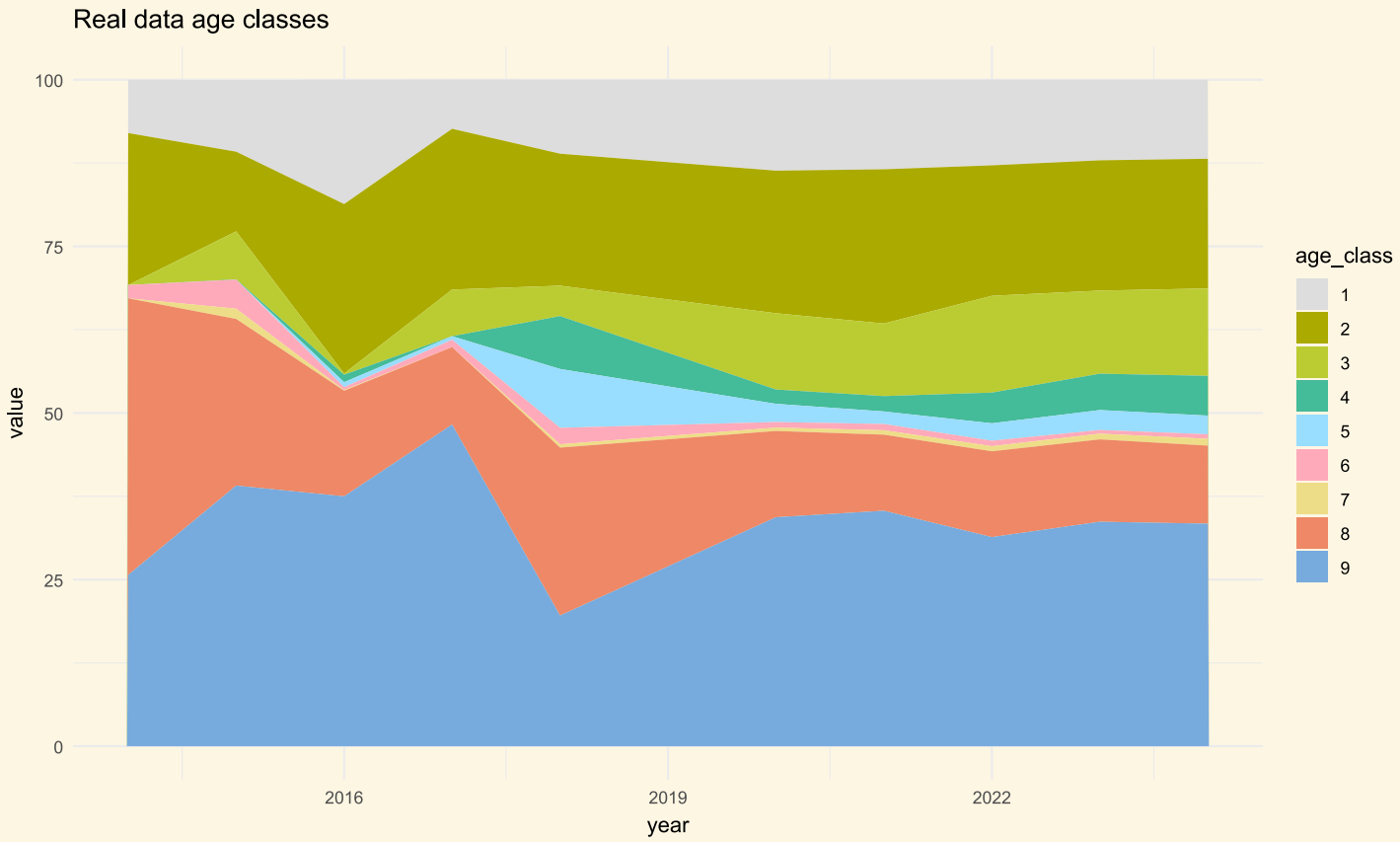


Comparing pseudo data to real data



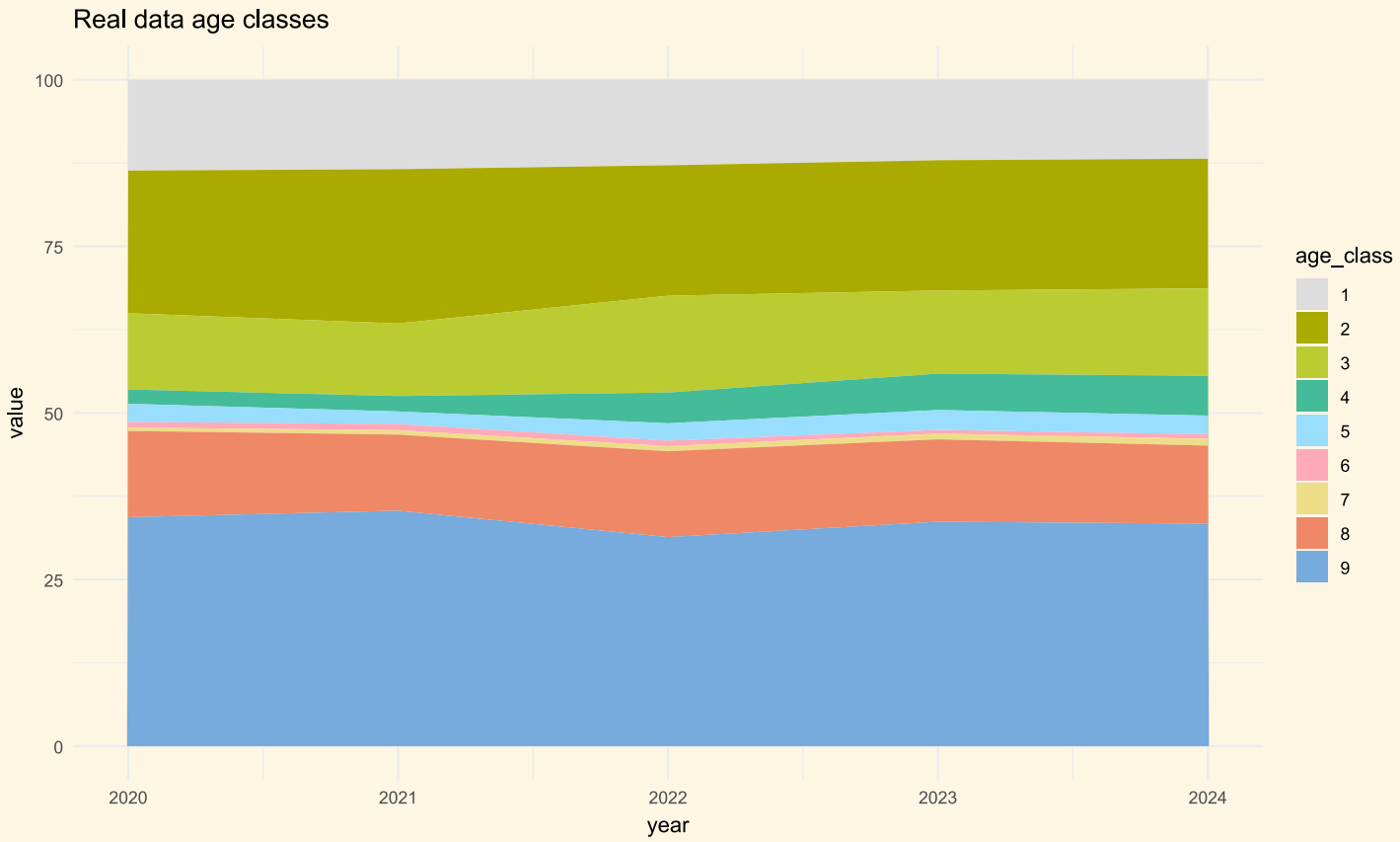
Comparing pseudo data to real data

Let's revisit the original figure from a few (dozen) slides ago...



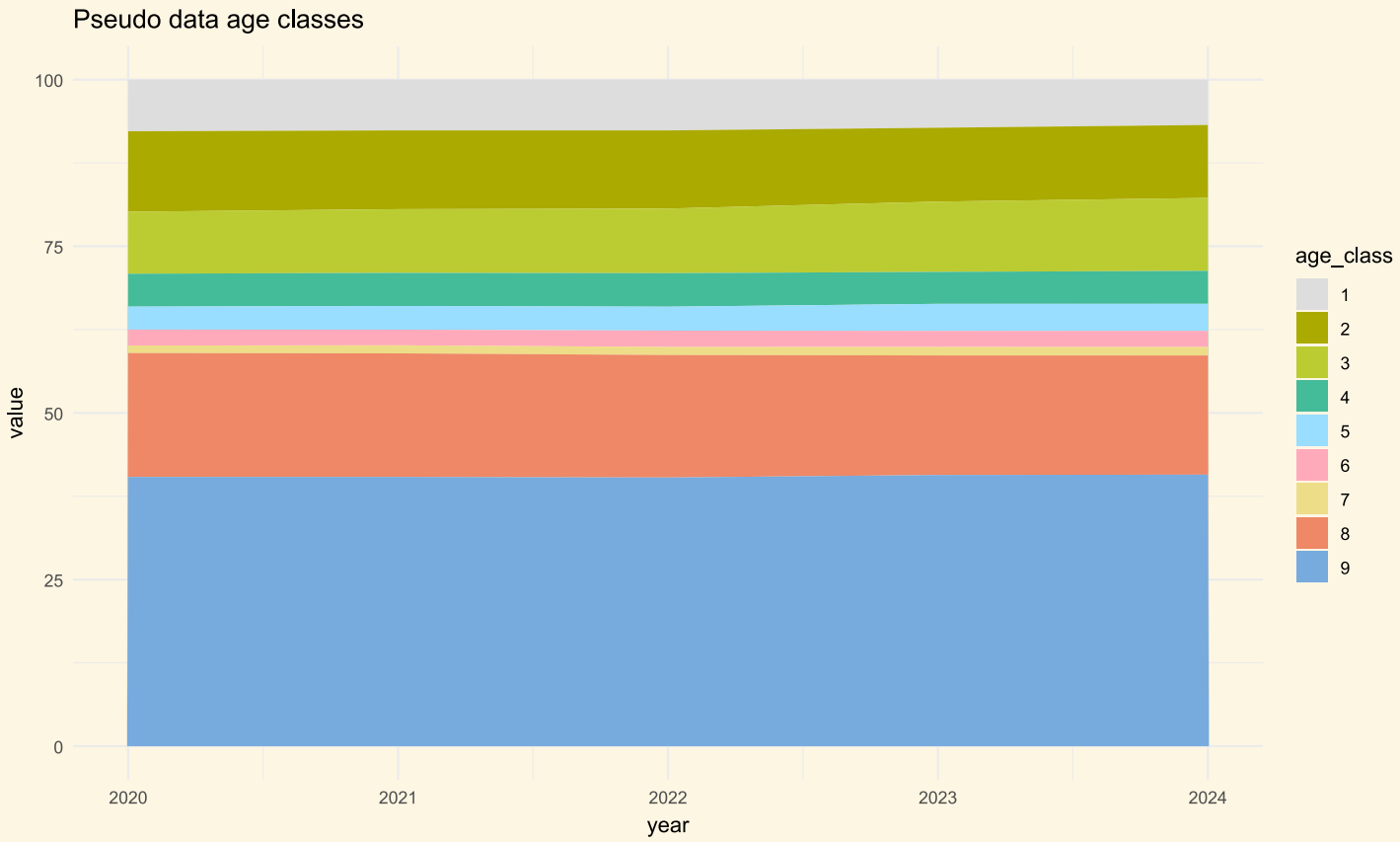
Comparing pseudo data to real data

Zoom in to 2020-2024, so it lines up with pseudo data...

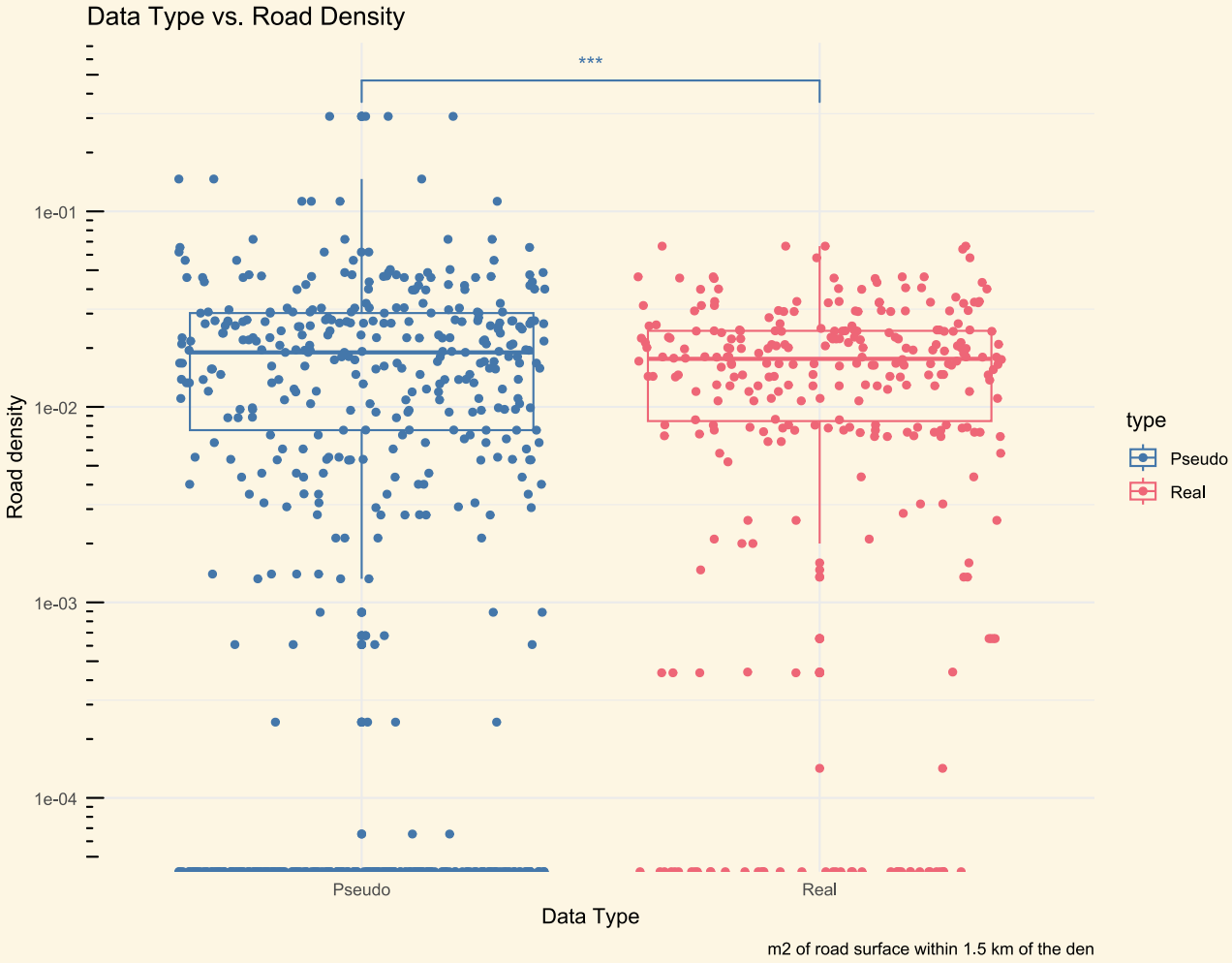


Comparing pseudo data to real data

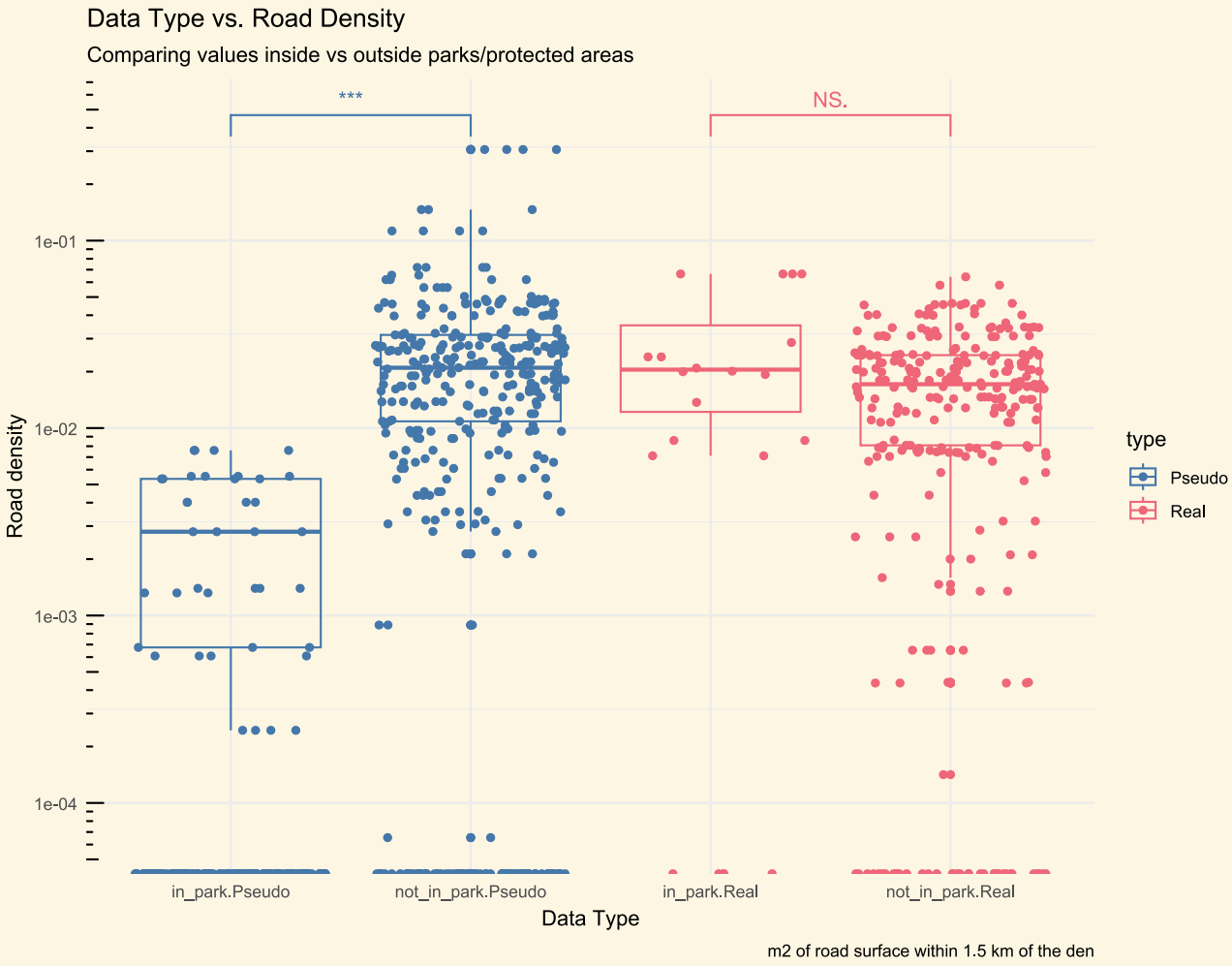
... and compare it to the *very* static age classes around pseudo data.



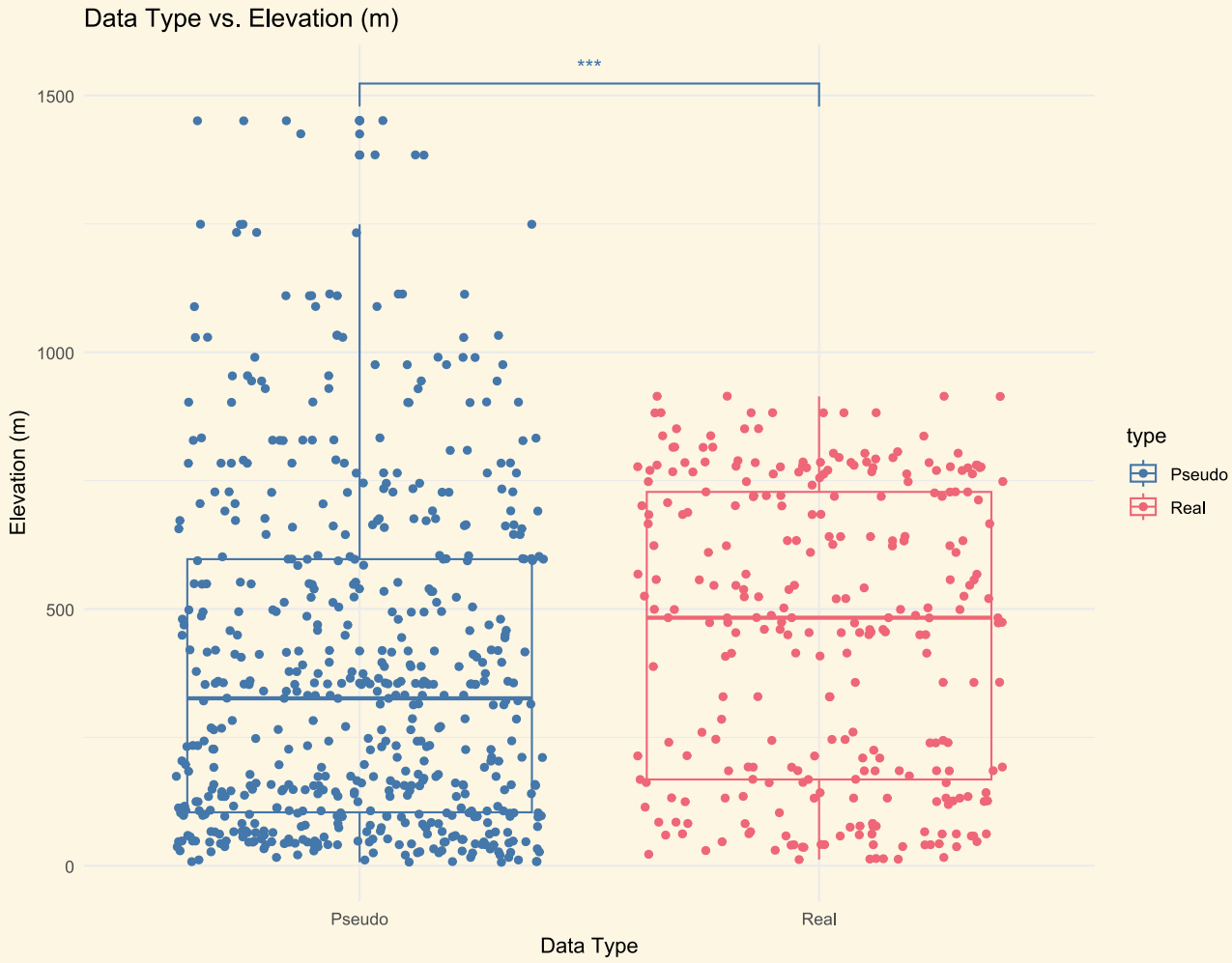
Comparing pseudo data to real data



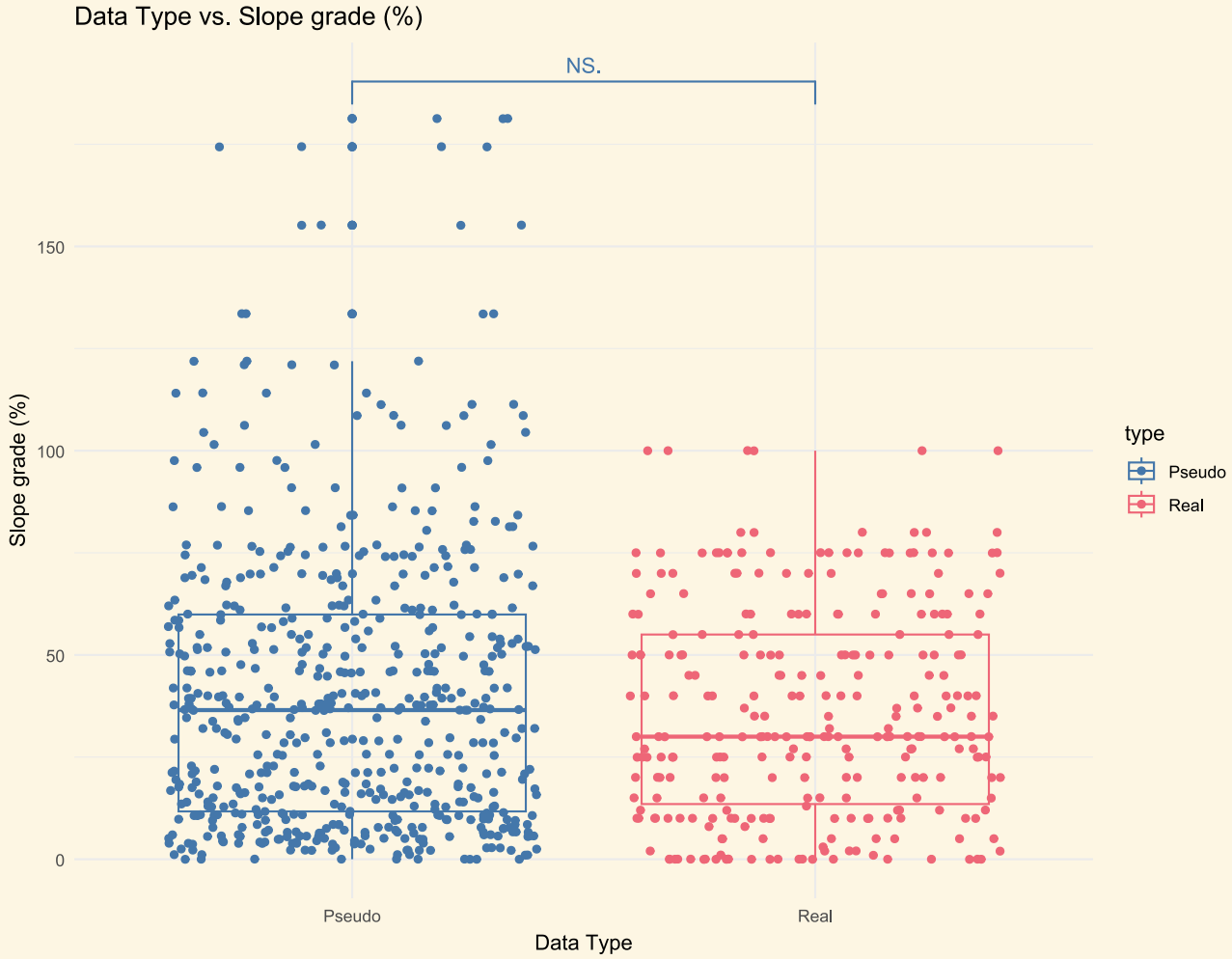
Comparing pseudo data to real data



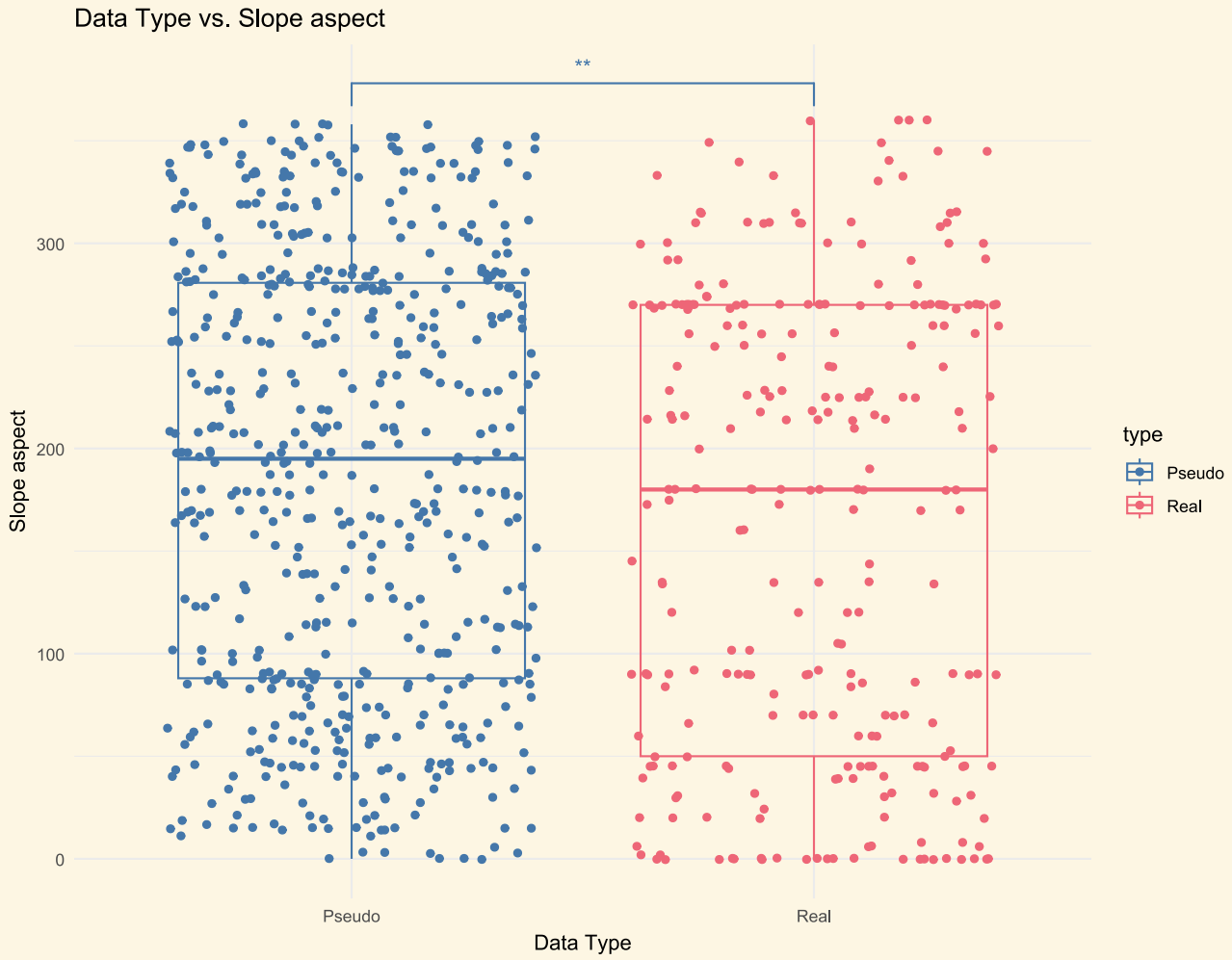
Comparing pseudo data to real data



Comparing pseudo data to real data



Comparing pseudo data to real data



Comparing pseudo data to real data

Takeaways:

- Randomly sampled points on the landscape are overwhelmingly more likely to have 100% forest coverage within 60 meters than our bear dens.
- The mean distance to recent cutblocks (forest <40 yo) is **significantly higher** for randomly sampled points than for our bear dens.
- For both random data points and bear dens, they are both more likely to be within a patch of mature forest (>40 yo) than not.
- The mean distance to nearest road is **significantly higher** for randomly sampled points than for our bear dens.
- Randomly sampled points, on average, have a higher proportion of old growth forest (age class > 7) within 1.5km than our bear dens.

Comparing pseudo data to real data

Ultimately, I think it's safe to say we *do not* have a random sample of dens, when it comes to both forestry treatments and geography.

Overall data summary

Good news:

- Considering the amount of effort it takes to collect this data, we have a large sample size across a large swath of the province
- This is the first dataset of its kind (to our knowledge)
- We can supplement this data with the huge backlog of camera data

Limitations:

- We don't have a large sample size -> low statistical power
- We don't have much variation between our various variables
- We don't have a representative (random) sample
- Uneven sampling effort across years and regions

Our research questions

Now we have had a nice and detailed tour of the data. What are our research questions? What can we try to answer with this data?

Our research questions

In a nutshell:

1. Does the stand condition around the den influence den activity (Active vs. Not active)?
2. Do non-forestry conditions (e.g., den characteristics) influence den activity?
3. Does forestry treatement affect windthrow impacts?
4. Does current management align with recommendations?

Our research questions

In a nutshell:

1. Does the stand condition around the den influence den activity (Active vs. Not active)?

1. Do non-forestry conditions (e.g., den size, geography) influence den activity?
2. Does windthrow affect den activity?
3. Does current management align with recommendations?

Question 1: Does stand condition affect den activity?

Let's focus on this one.

Question 1

Question: How does stand-level condition, including distance to road, proportion forested, and distance to edge, and landscape-level condition (road density, proportion <40 years, proportion >250 years within 1.5km), relate to den use the following winter?

Question 1

Question: How does stand-level condition, including distance to road, proportion forested, and distance to edge, and landscape-level condition (road density, proportion <40 years, proportion >250 years within 1.5km), relate to den use the following winter?

Prediction: The likelihood of den use over time is positively correlated with distance to <40 years, distance to road, proportion forested, and negatively correlated with distance to >40 years. Landscape condition may have different responses based on condition; at very low road density, and low <40 years, and high >250 years, den use may be less correlated with stand-level condition as we presume more options for bear to use, which means den use may be lower or more sensitive to stand-level variation.

Question 1

Candidate models:

```
den status ~ year # control for yearly variation in bear activity
den status ~ region # do dens have different usage by region?
den status ~ proportion forested # do dens with more intact forest have more a
den status ~ distance <40 # do dens further from cutblocks have more activity?
den status ~ distance >40 # do dens further from old growth have less activity
den status ~ distance to road # do dens further from roads have more activity?
den status ~ road density # do dens with higher road density have less activit
den status ~ stand age # do dens in older stand age have more activity?
den status ~ % old growth # do dens with higher % old growth nearby have more
den status ~ % new growth # do dens with higher % new growth nearby have less

# + interactions with stand age
den status ~ distance to road * stand age # does distance to road matter in ol
```

Though, note that all models include `+ age + year` to control for whether the den is in intact mature forest vs a cutblock plus control for yearly variation in activity.

Question 1

In addition to these simple one variable models, we also tried a "kitchen sink" approach, with all non-correlated variables within a single model:

```
# Kitchen sink 1
den status ~ year + region + proportion forested +
distance to edge * stand age +
road density

# Kitchen sink 2
den status ~ year + region + proportion forested +
distance to road * stand age
```

Question 1

Data summary:

- Colinear model terms are excluded from the full "kitchen sink" model.
- Data are strictly filtered down to "Active" and "Not Active" dens where we *for sure* know the den status. I.e., exluding "Active within past 4 years" or "Unknown" status dens.

Question 1

By far and away, our base model `model00` is consistently one of the top models, in any variation of models we tried.

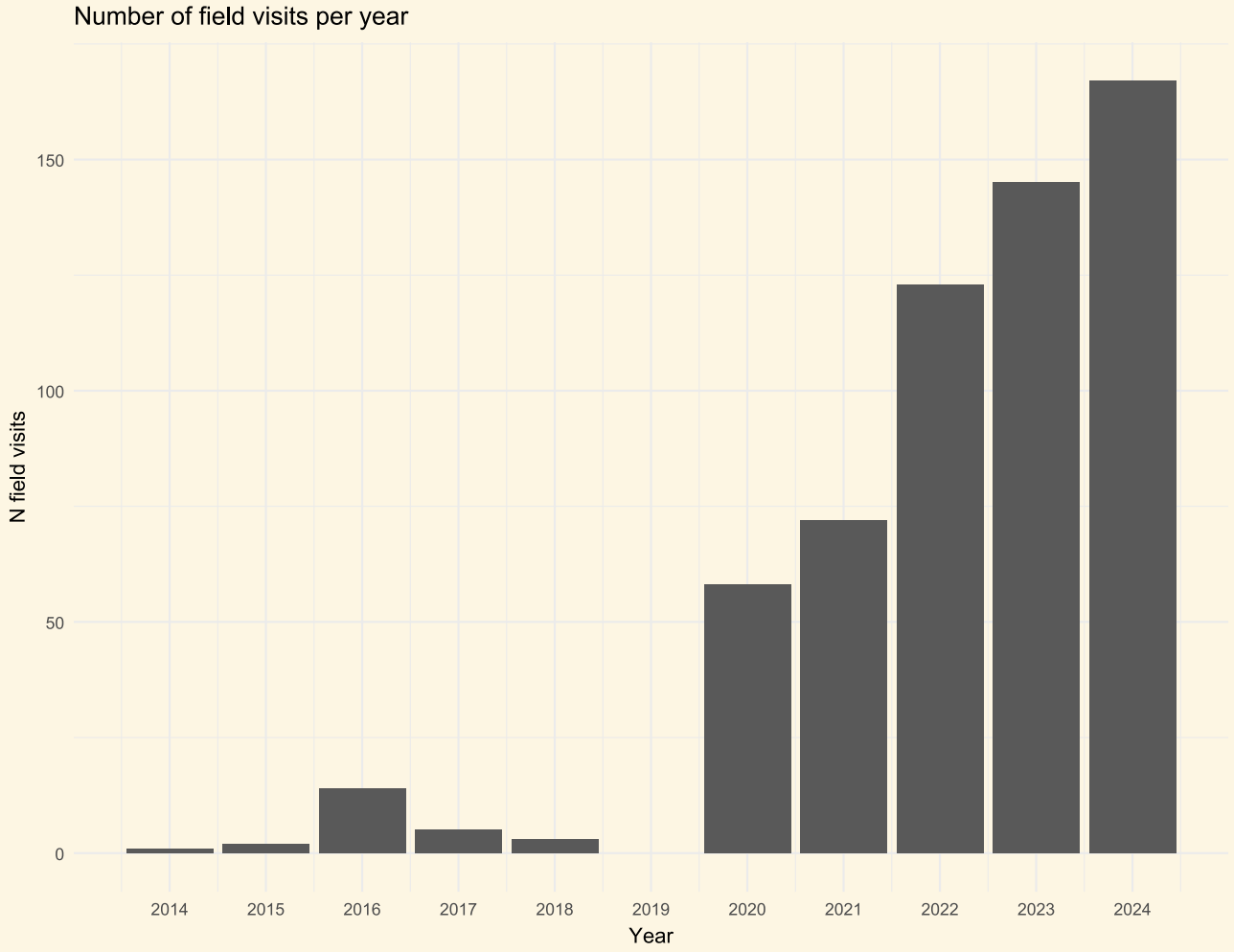
```
## dAIC df weight
## model0f2 0.0 8 0.1650
## model0g1 0.1 4 0.1591
## model00 1.1 2 0.0959
## model0d 1.3 3 0.0854
## model0g2 1.8 5 0.0672
## model0n 2.1 5 0.0586
## model0e 2.7 4 0.0421
## model0j 2.8 4 0.0405
## model0r 2.9 3 0.0382
## model0c 3.0 4 0.0366
## model0b 3.0 4 0.0362
## model0i 3.2 4 0.0326
## model0k 3.3 4 0.0319
## model0a 3.3 4 0.0318
## model0f1 4.7 5 0.0155
## model0g3 4.8 8 0.0153
## model0l 5.0 5 0.0134
## model0m 5.2 5 0.0121
## model1b 5.4 7 0.0109
```

Question 1

`model00` happens to be the base model that simply tries to control for decreases in bear den activity (because of low rates of reuse) as a result of more dens monitored over time...

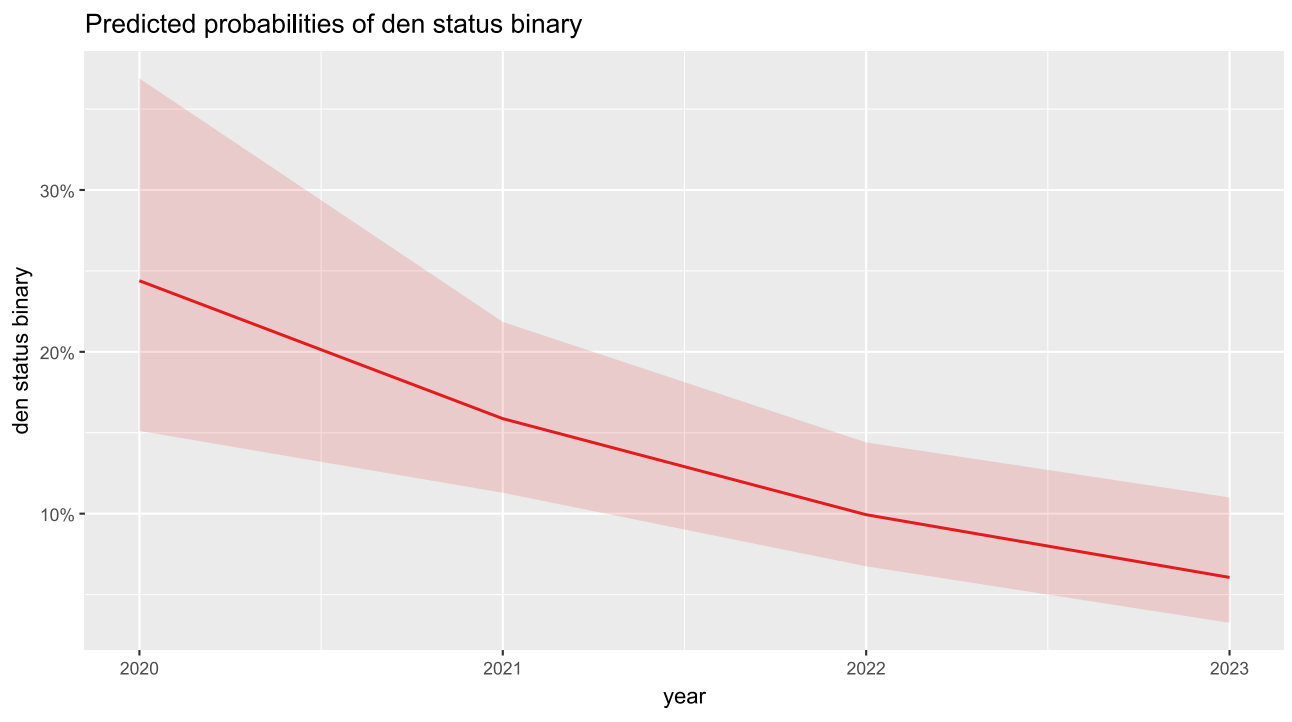
```
##
## Call:
## glm(formula = den_status_binary ~ year, family = binomial, data = dat)
##
## Coefficients:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) 1082.6111 343.4602 3.152 0.00162 **
## year -0.5365 0.1699 -3.158 0.00159 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 202.82 on 278 degrees of freedom
## Residual deviance: 192.60 on 277 degrees of freedom
## AIC: 196.6
##
## Number of Fisher Scoring iterations: 5
```

Question 1


Number of field visits per year
N field visits
150
100
50
0
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Year

Question 1

And it so happens that, because of the really low den re-use rate, as time goes on, the likelihood of a den being active again is quite low. Therefore, as `year` increases, your likelihood of being an "Active" den *decreases*.



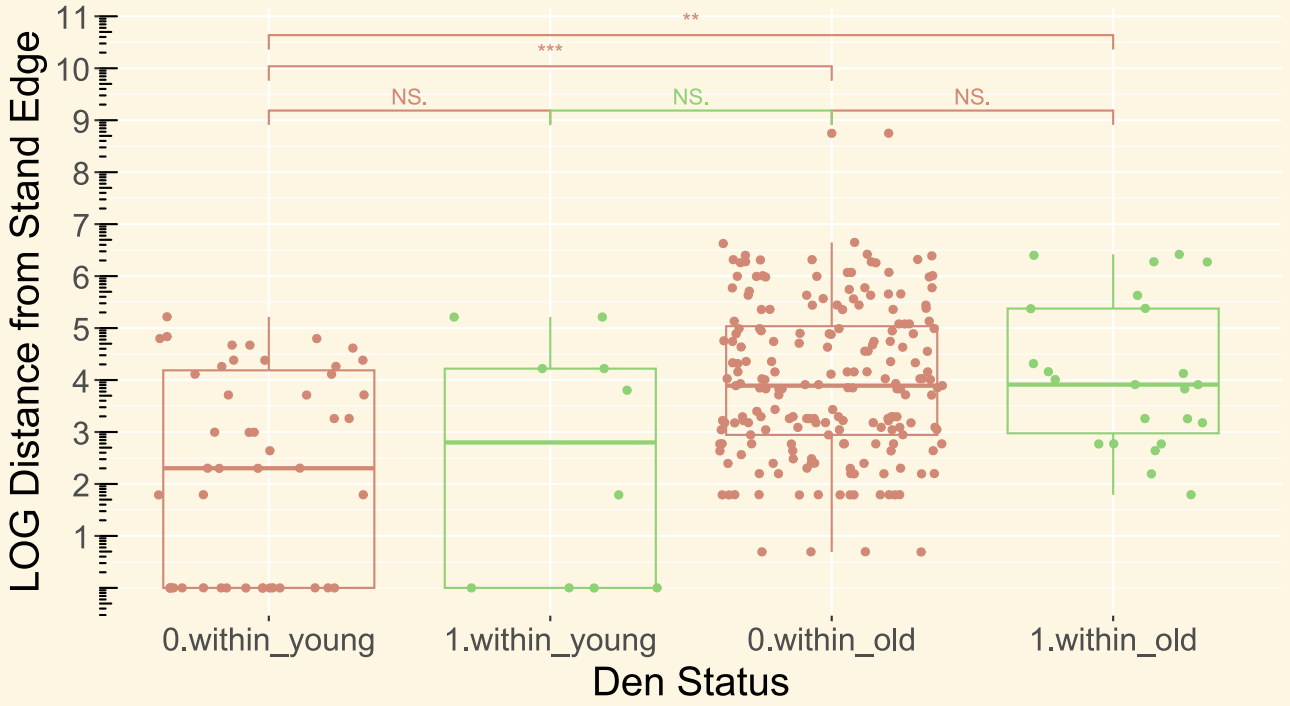
Question 1

But what about the top model???

```
##
## Call:
## glm(formula = den_status_binary ~ log_dist_from_edge * age *
## year, family = binomial, data = dat)
##
## Coefficients:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) 4771.5780 1955.1394 2.441 0.01467 *
## log_dist_from_edge -1159.8103 502.4264 -2.308 0.02098 *
## agewithin_old -5964.1069 2343.9584 -2.544 0.01094 *
## year -2.3619 0.9677 -2.441 0.01465 *
## log_dist_from_edge:agewithin_old 1713.0425 589.2383 2.907 0.00365 **
## log_dist_from_edge:year 0.5739 0.2486 2.308 0.02098 *
## agewithin_old:year 2.9506 1.1599 2.544 0.01096 *
## log_dist_from_edge:agewithin_old:year -0.8475 0.2915 -2.907 0.00365 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 202.82 on 278 degrees of freedom
## Residual deviance: 179.52 on 271 degrees of freedom
## AIC: 195.52
##
## Number of Fisher Scoring iterations: 6
```

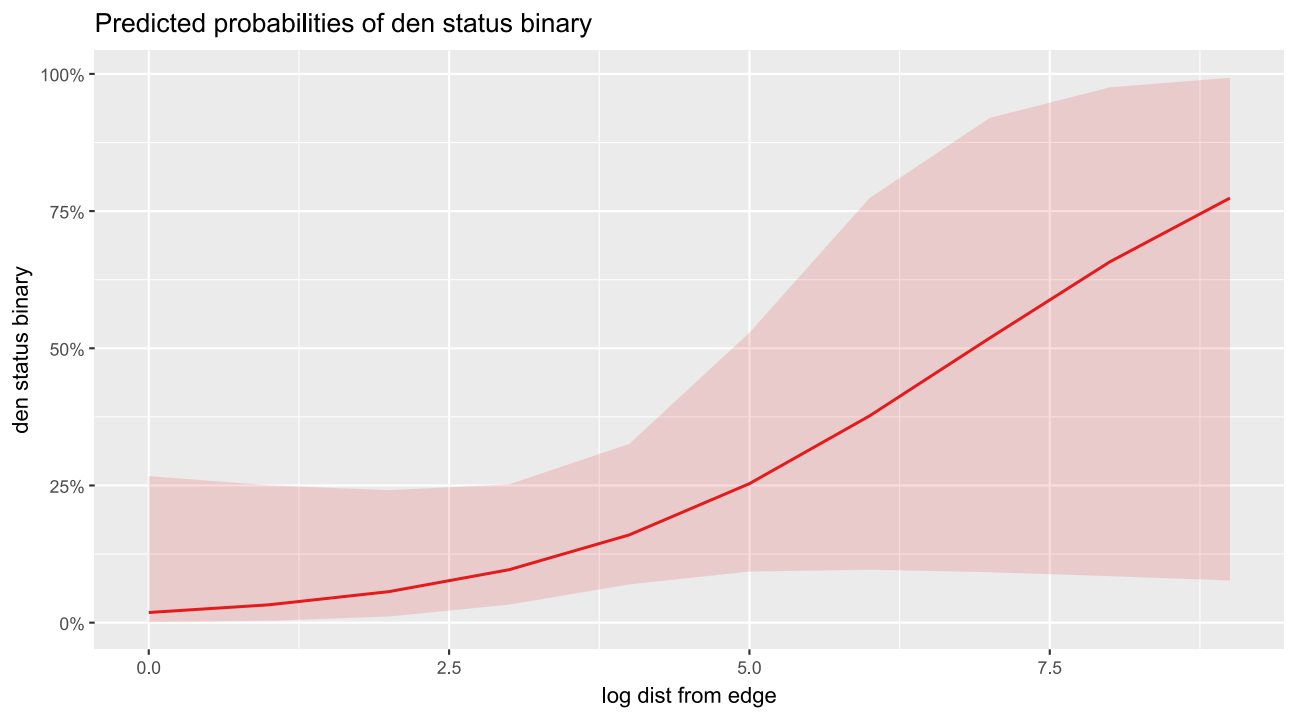
Question 1: Top Model 1 Summary

The relationship is different between young stands versus old, mature stands. In general, dens within old/mature stands tend to be further from the cutblock edge, while dens within young/cutblock stands tend to be close to the edge of mature forests.



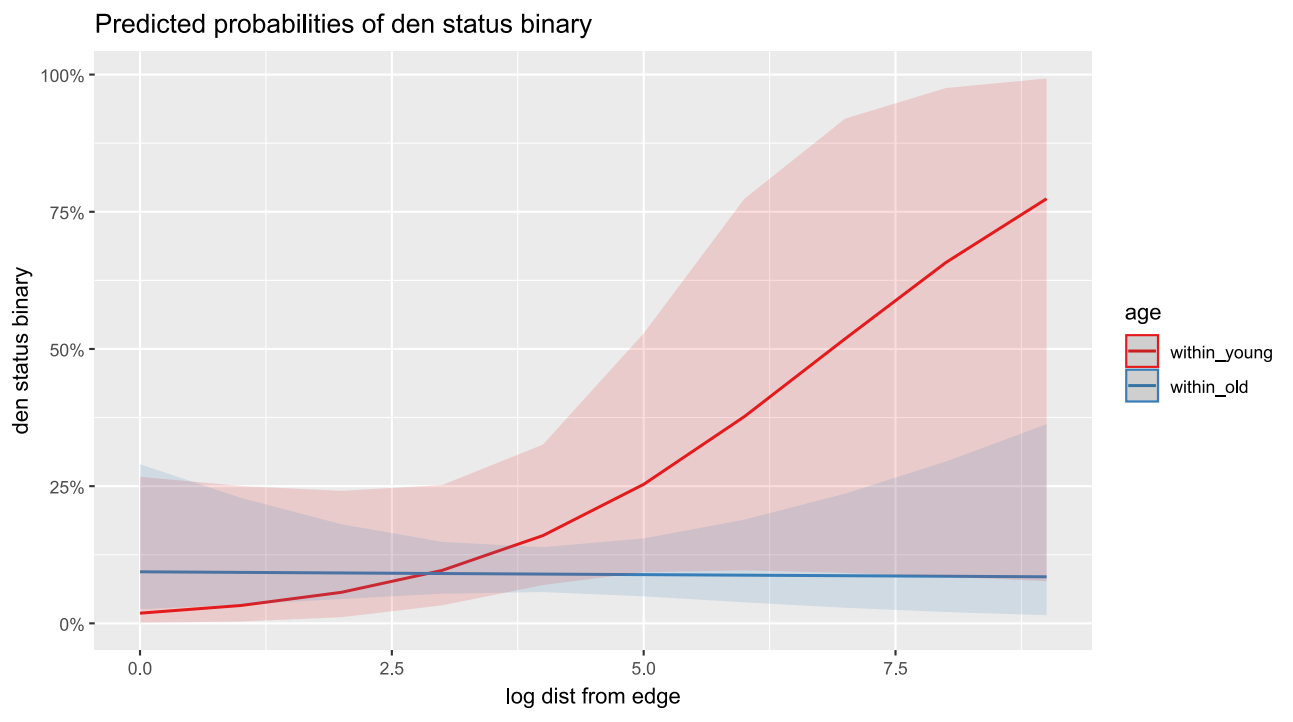
Question 1: Top Model 1 Summary

As distance from the cutblock edge increases, the chances of being "Active" also go up.



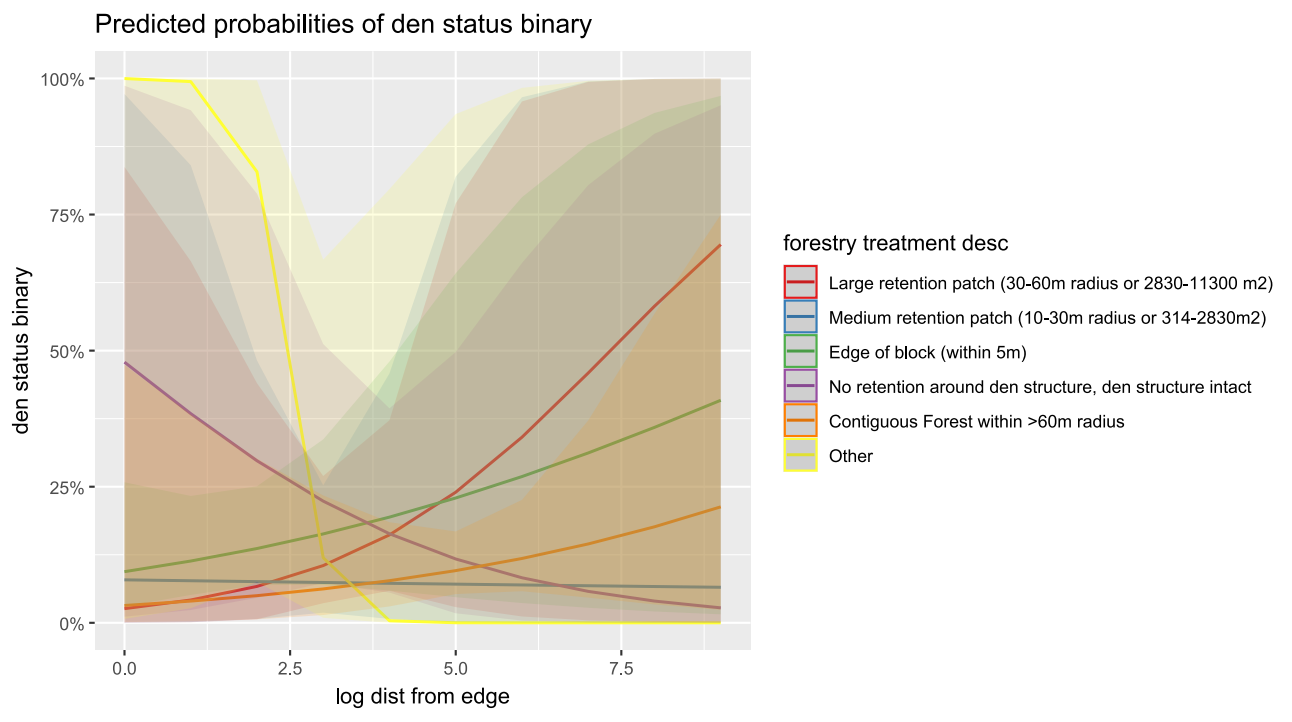
Question 1: Top Model 1 Summary

It gets complicated when we look at the interaction with age. There's more to tease out from these results. In short, the distance from the edge of the block matters *more* in young stands than old.



Question 1: Top Model 1 Summary

If you want to get even more fine grained, the relationship between "Active" probability and the *type* of forest stand is variable, though not statistically significant.



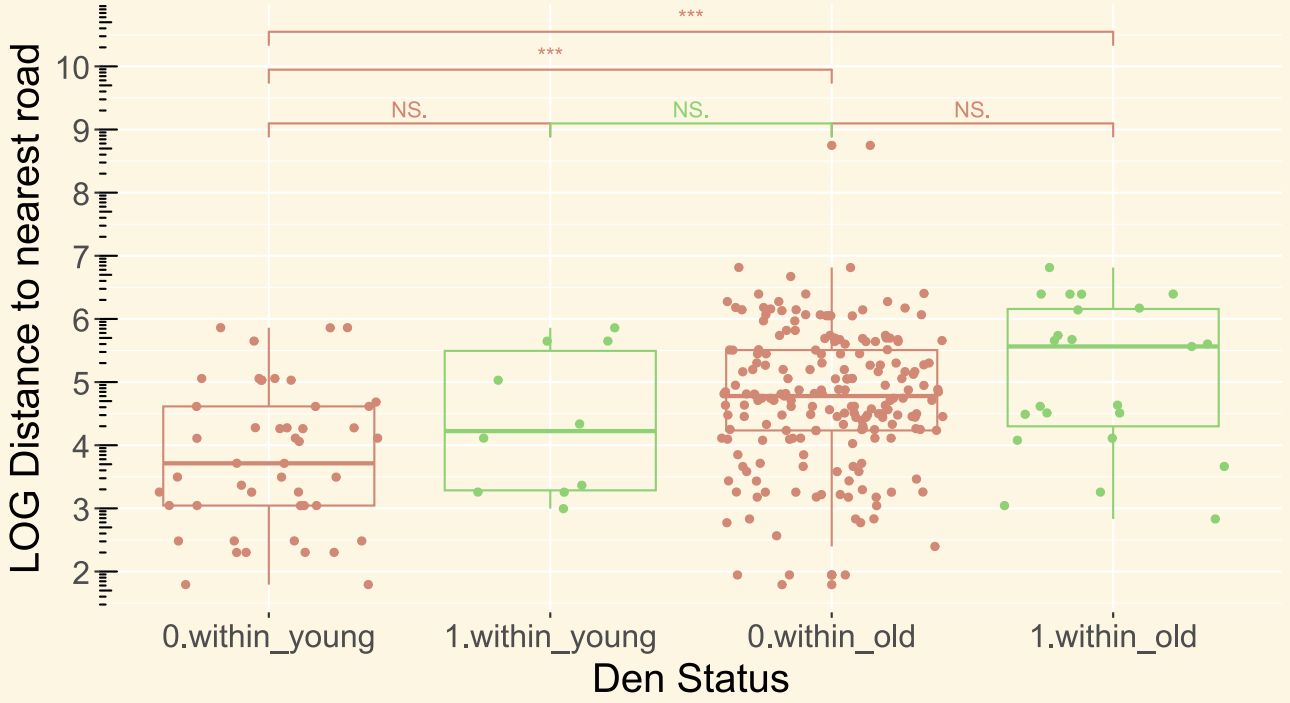
Question 1: Top Model 2 Summary

The next-best fit is the model that incorporates distance from forest road, rather than distance from cutblock edge.

```
##
## Call:
## glm(formula = den_status_binary ~ log_dist_road + age + year,
## family = binomial, data = dat)
##
## Coefficients:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) 1045.7677 346.4568 3.018 0.00254 **
## log_dist_road 0.3231 0.1819 1.776 0.07567 .
## agewithin_old -0.8795 0.4592 -1.916 0.05542 .
## year -0.5187 0.1714 -3.027 0.00247 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 202.82 on 278 degrees of freedom
## Residual deviance: 187.59 on 275 degrees of freedom
## AIC: 195.59
##
## Number of Fisher Scoring iterations: 5
```

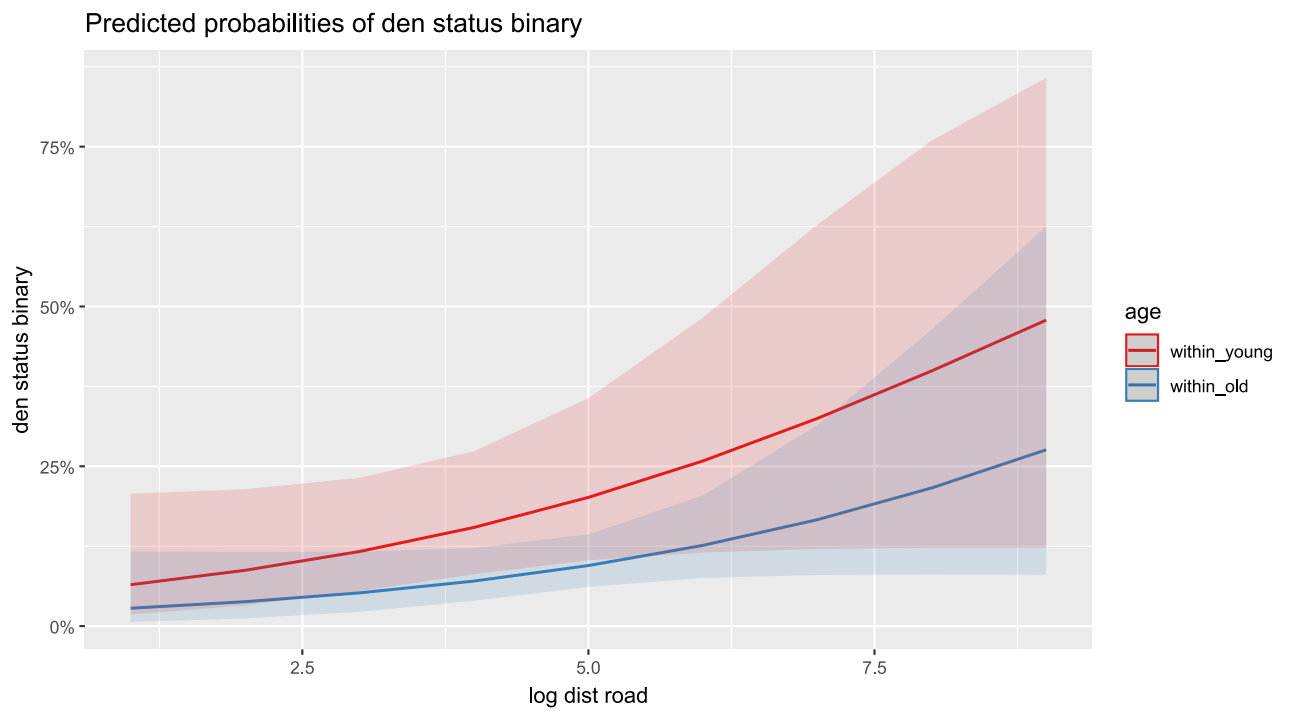
Question 1: Top Model 2 Summary

This model tells a similar story! If a den is **close to a road** and **within a cutblock**, it's statistically more likely to be **NOT ACTIVE!**



Question 1: Top Model 2 Summary

In the case of the roads, it doesn't matter what the age of the stand is: the further away from the road you are, the more likely you are to find an Active den.



Question 1

When we go more lenient with our strict data criteria, and decide to include "Active within last 4 years" as "Active", rather than "Unknown", we get nearly identical results.

Question 1

Activity status in general is fairly objective and can be difficult to define. There were a fair bit of 'Uknown' den statuses. What if we are interested in seeing whether or not a den was checked out *at all*?

What about modeling the response variable as `hair_in_bed`?

Question 1

Activity status in general is fairly objective and can be difficult to define. There were a fair bit of 'Uknown' den statuses. What if we are interested in seeing whether or not a den was checked out *at all*?

What about modeling the response variable as `hair_in_bed`?

- It's more objective than the activity status column.
- But, it simply tells us whether or not a bear has visited the den.

Question 1 *ish*

Candidate models:

```
hair in den ~ year
hair in den ~ region + age + year
hair in den ~ proportion forested + age + year
hair in den ~ distance <40 + age + year
hair in den ~ distance >40 + age + year
hair in den ~ distance to road + age + year
hair in den ~ road density + age + year
hair in den ~ stand age + age + year
hair in den ~ % old growth + age + year
hair in den ~ % new growth + age + year

# + interactions with stand age
hair in den ~ distance to road * stand age + year

# + full model
hair in den ~ year + region + proportion forested +
distance to edge + stand age +
road density
```

Question 1 *ish*

The full "kitchen sink" model is the best fit in this case. It shows that for dens that are in old forest and further from the cutblock edge, there is a higher probability of finding some bear hairs.

```
##
## Call:
## glm(formula = y ~ year + region + f_prop_forest_60m + log_dist_from_edge *
## age + road_density_m2, family = binomial, data = dat)
##
## Coefficients:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) 1.328e+03 2.996e+02 4.432 9.33e-06 ***
## year -6.596e-01 1.481e-01 -4.452 8.49e-06 ***
## regionVI -1.380e+00 5.241e-01 -2.634 0.00844 **
## f_prop_forest_60m -4.809e-03 1.077e-02 -0.447 0.65517
## log_dist_from_edge 1.309e+00 7.150e-01 1.831 0.06709 .
## agewithin_old 6.525e+00 3.191e+00 2.045 0.04089 *
## road_density_m2 1.345e+00 1.136e+01 0.118 0.90579
## log_dist_from_edge:agewithin_old -1.448e+00 7.606e-01 -1.903 0.05702 .
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 292.99 on 264 degrees of freedom
## Residual deviance: 260.09 on 257 degrees of freedom
## (21 observations deleted due to missingness)
## AIC: 276.09
##
## Number of Fisher Scoring iterations: 6
```

Question 1: overall summary

- `year` explained much of the variance - likely because we visited many more dens in later years rather than older years.
- Distance from cutblock edge and distance from forest road jumped out as important. In general, dens are more likely to be active the further from a cutblock edge or forestry road that they are!

Ways forward?

- Perhaps some sort of weights/error structure can account for year without it "swamping" the model?
- Perhaps a bootstrapping approach to account for uneven years sampling: pull a random year of data - one per each den - then fit the model. Do this 1000x. Take the model averages.
- Perhaps running piecewise models: one for 'pre disturbance' den data, one for 'post disturbance'?
- Non-linear modeling approaches: perhaps a principal components analysis (PCA)?
- And finally, and perhaps most likely, we simply **need a greater sample size.** A priori power analysis indicated we'd need >400 dens sampled, but the modeling dataset is only 286 data points!

Question 2: Do non-forestry conditions influence den activity?

Question 2

Question: How do intrinsic den characteristics, such as den cavity size and shape, tree species, or position on the slope relate to den use?

Question 2

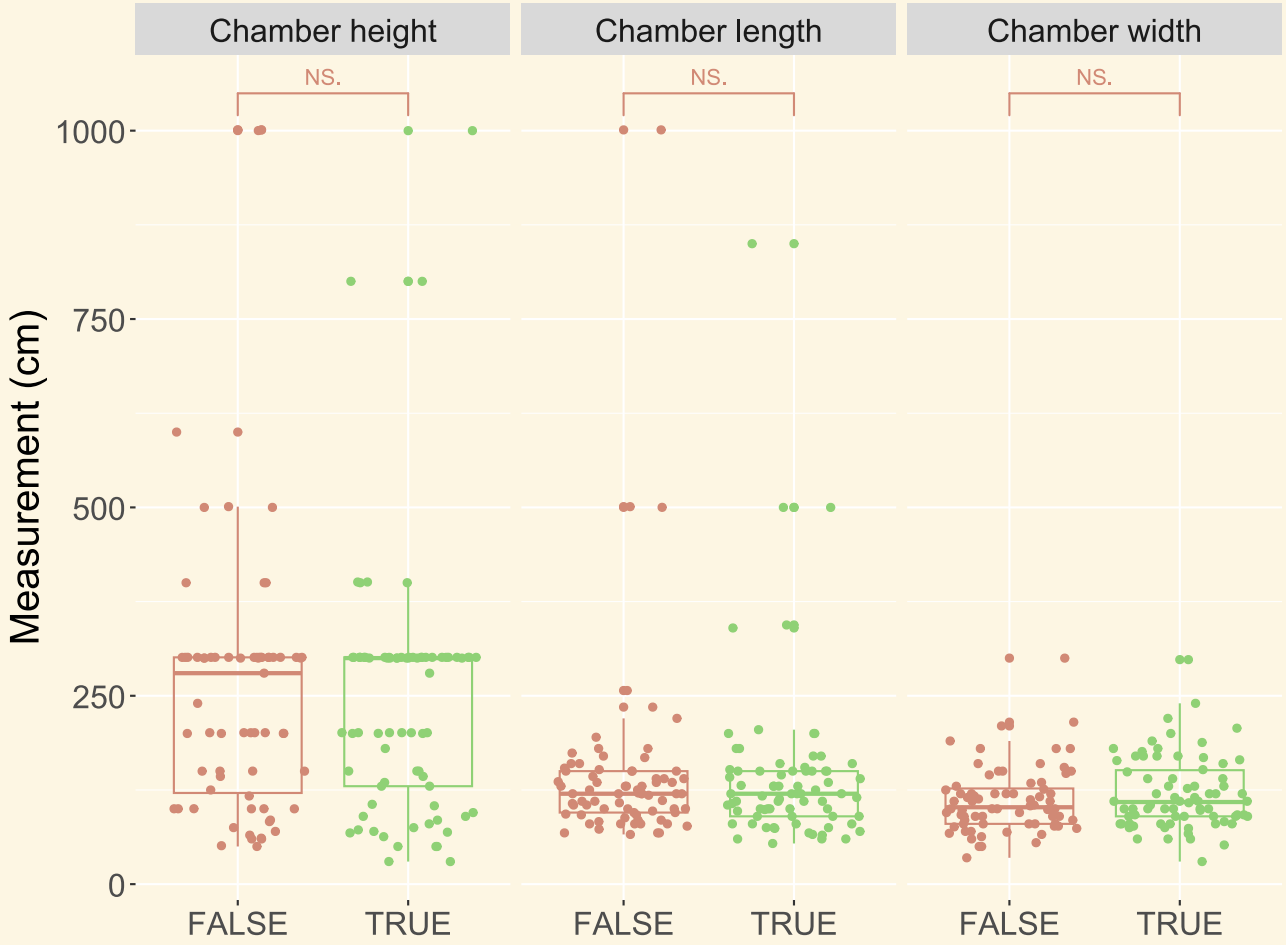
Question: How do intrinsic den characteristics, such as den cavity size and shape, tree species, or position on the slope relate to den use?

Prediction: The likelihood of den use is positively correlated with certain den sizes, tree species, and slopes.

For all the following plots, the response variable indicates whether or not the den was *ever* active (`ever_active_yn == TRUE`) or has *never* been active (`ever_active_yn == FALSE`). This is done to reduce psuedoreplication (many repeats of static den measurements versus changing den status each year), such that there is one data point per den (single static den measurements versus single "was the den active" response).

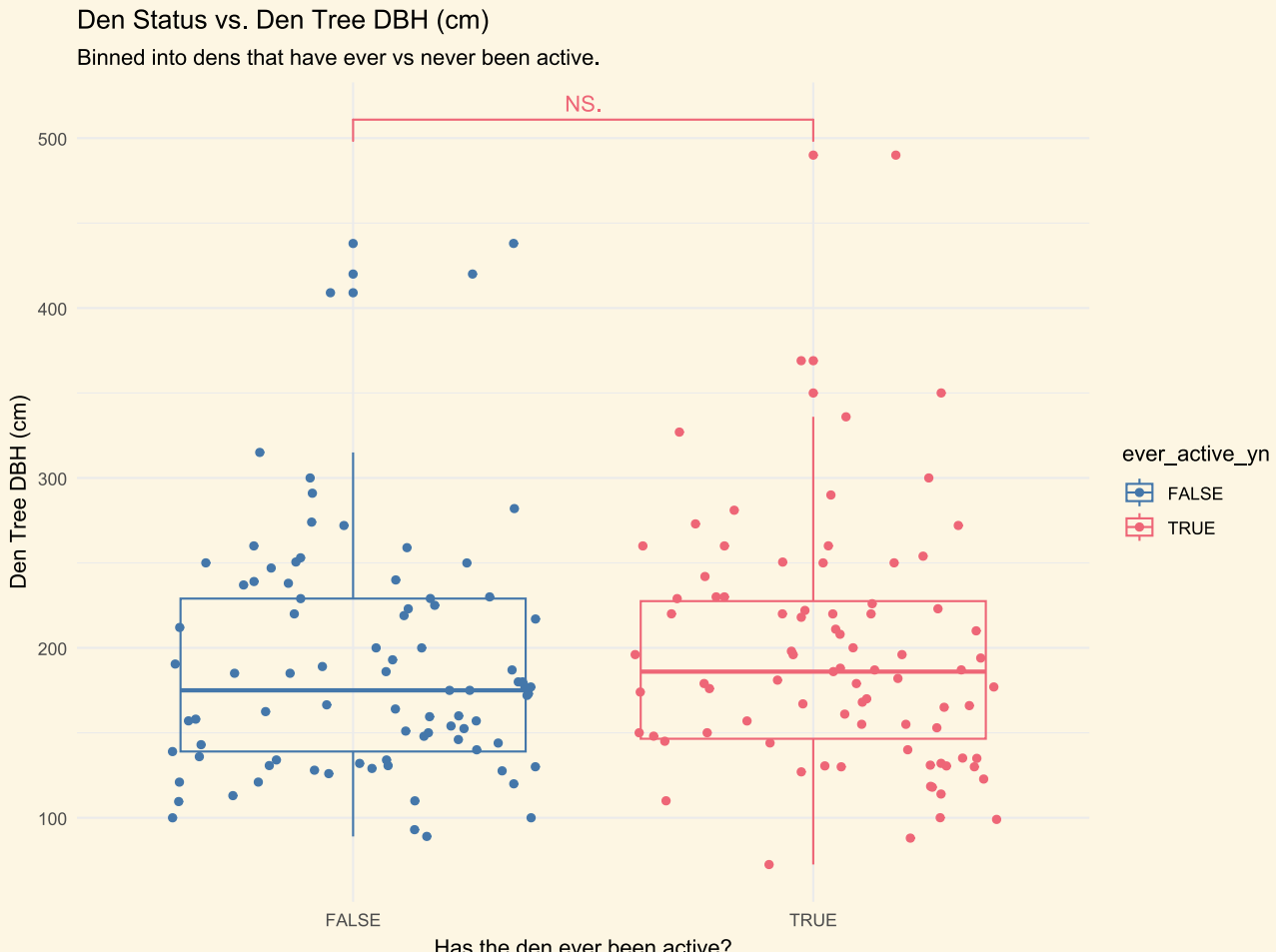
Chamber dimensions vs Den Status

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.



DBH vs Den Status

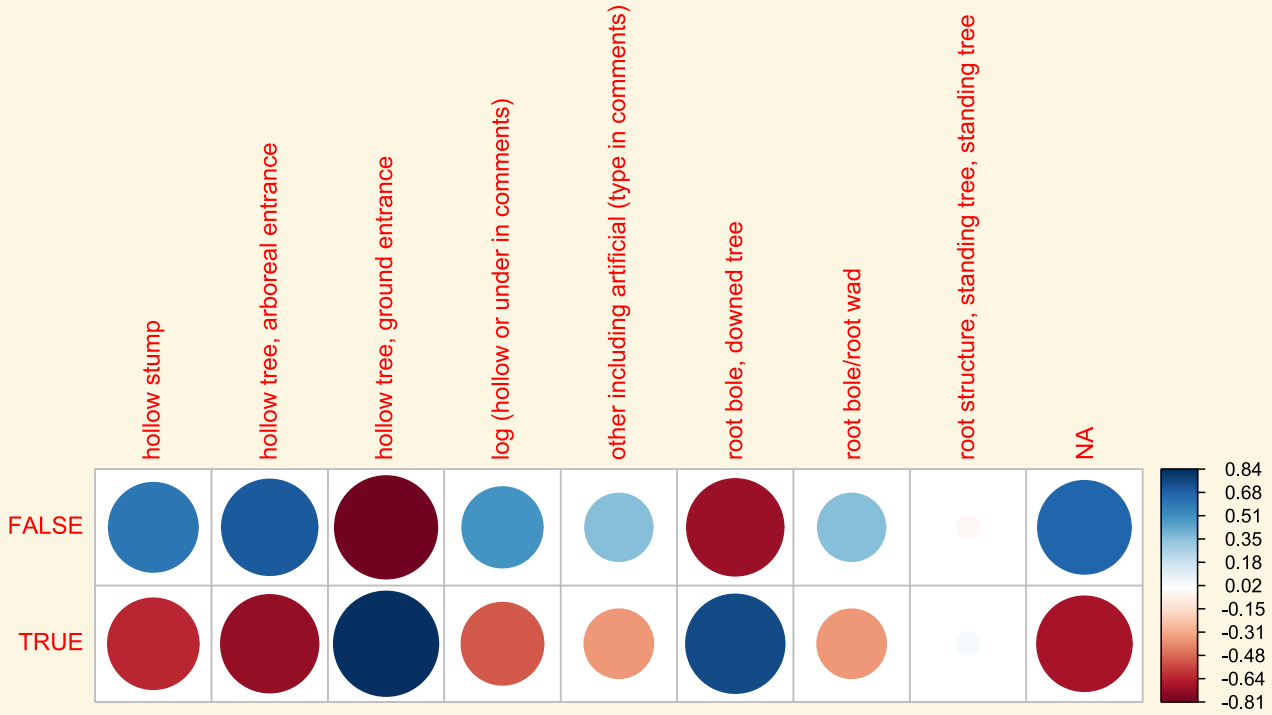
TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.



Den type vs Den Status

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.

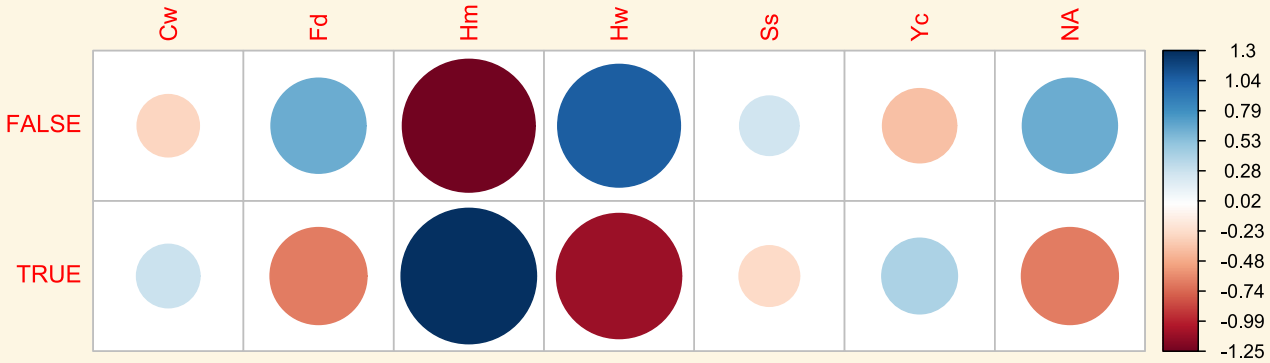
Root bole type dens disproportionately have more activity.



Den tree species vs Den Status

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.

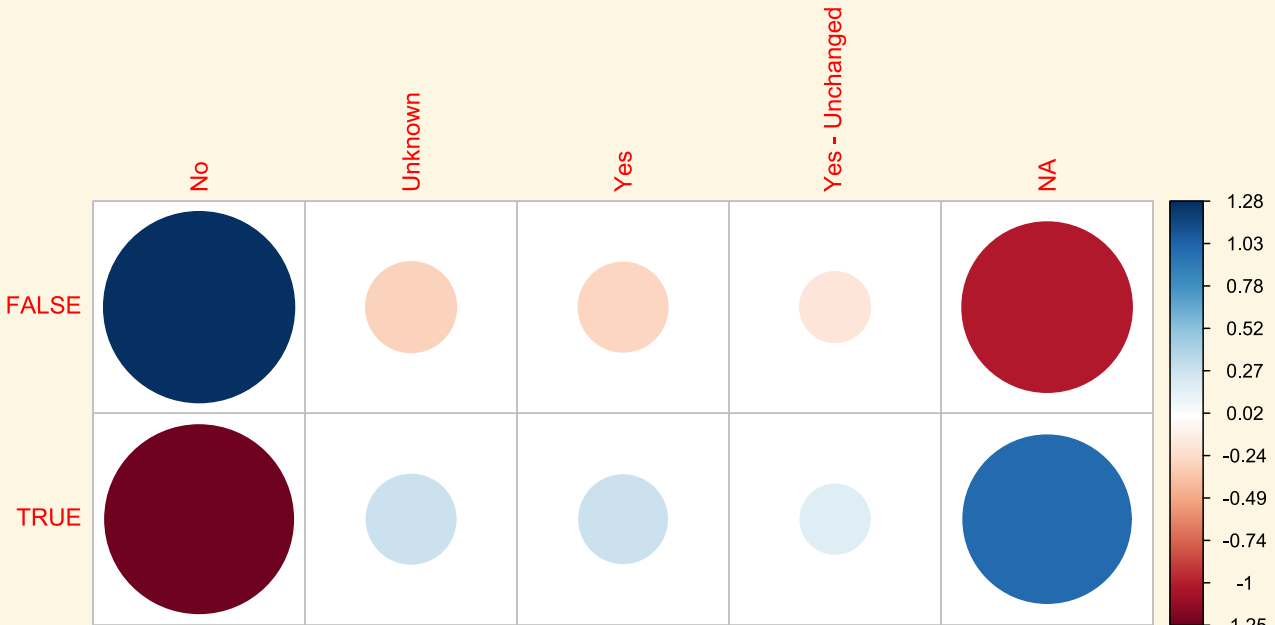
Root bole type dens disproportionately have more activity.



Bed Cup vs Den Status

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.

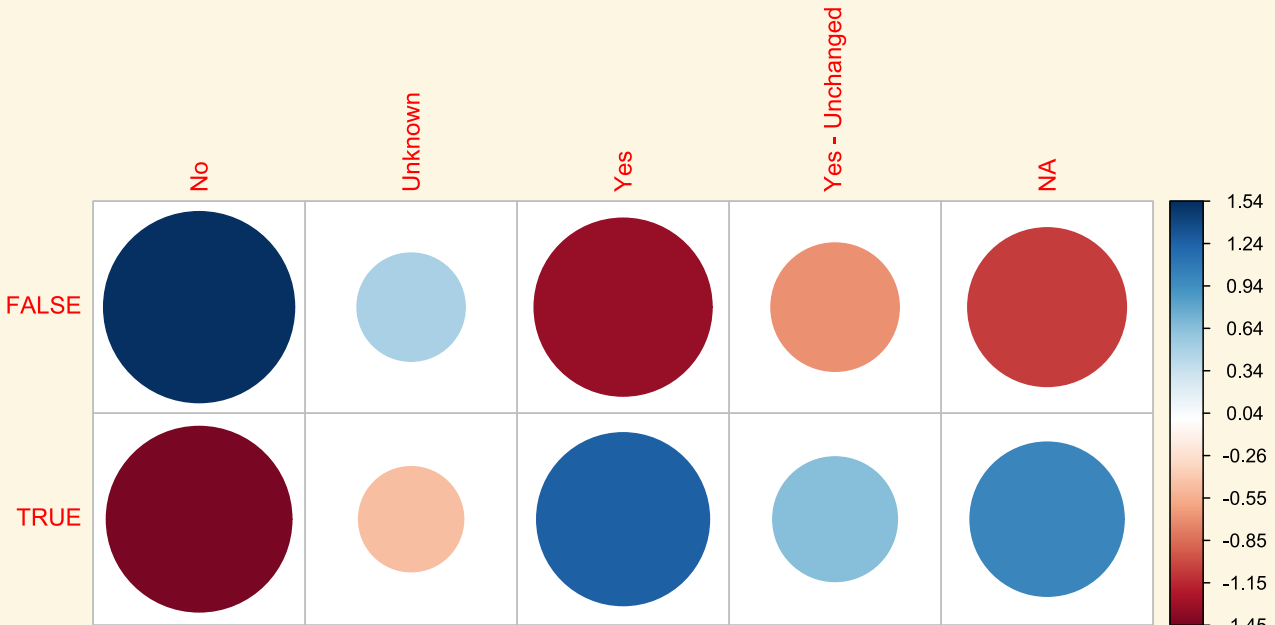
Active dens disproportionately have a bedding cup (makes sense - it's one of the decision criteria).



Hair in Bed vs Den Status

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.

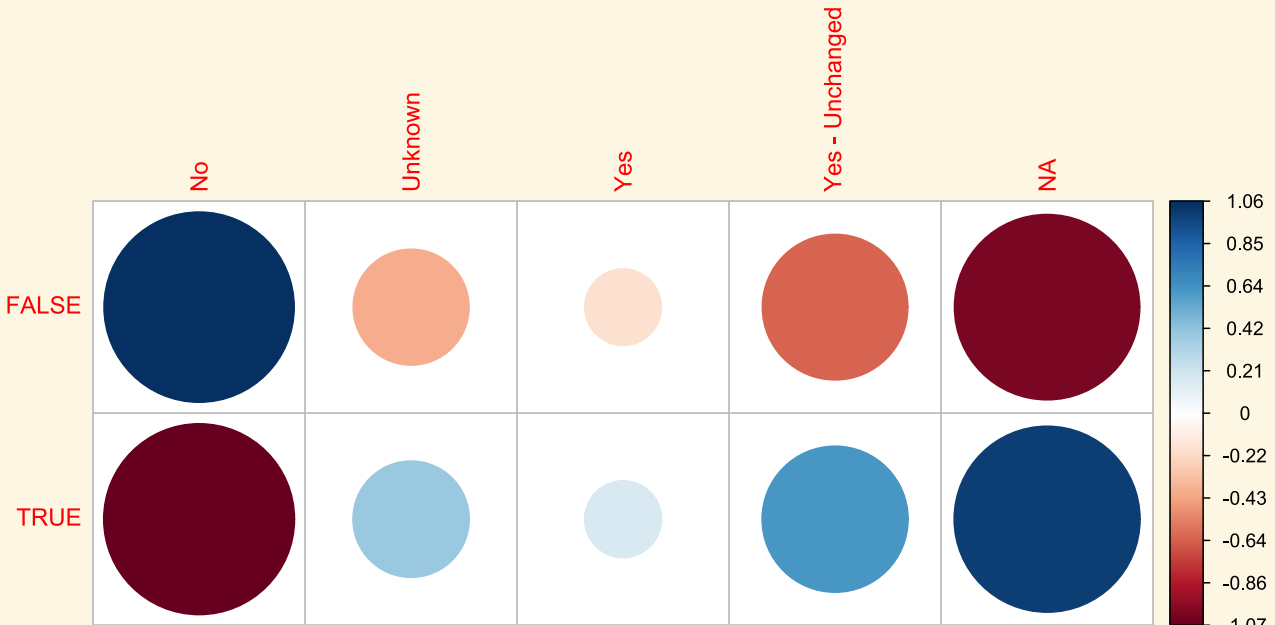
Active dens disproportionately have hair in the bed (makes sense - it's one of the decision criteria).



Hair on Entrance vs Den Status

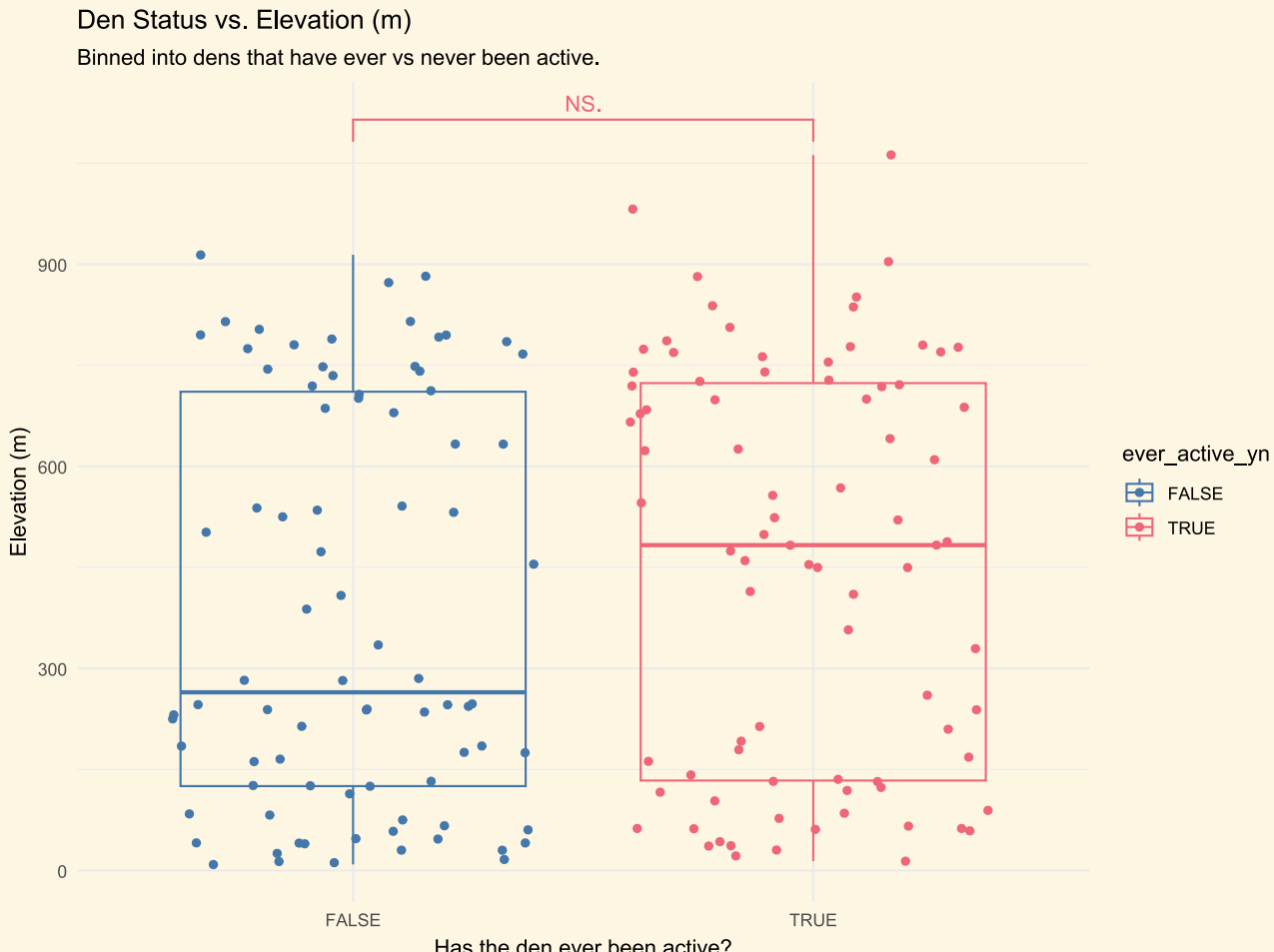
TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.

Active dens disproportionately have hair on the entrance (makes sense - it's one of the decision criteria).



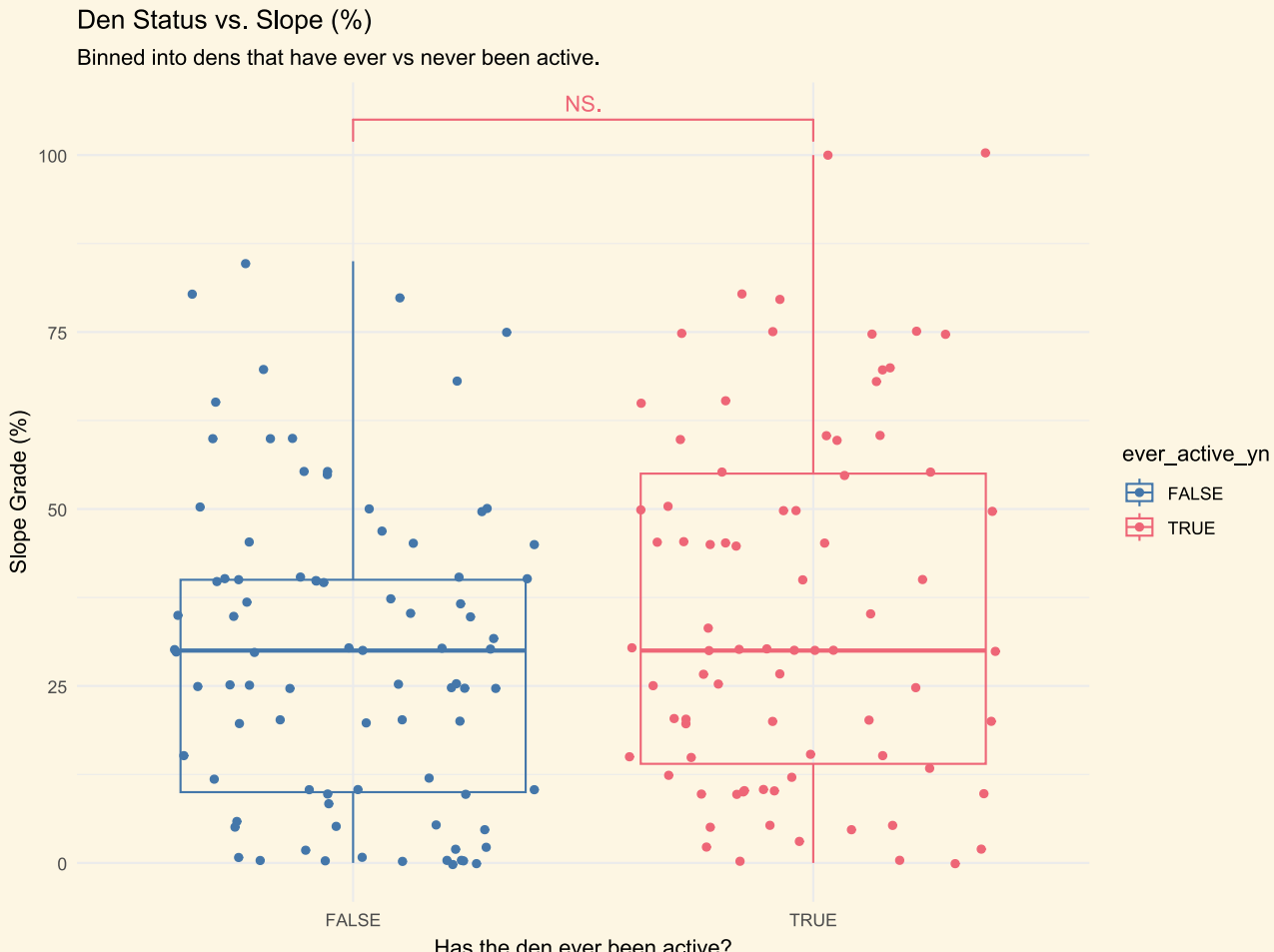
Elevation

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.



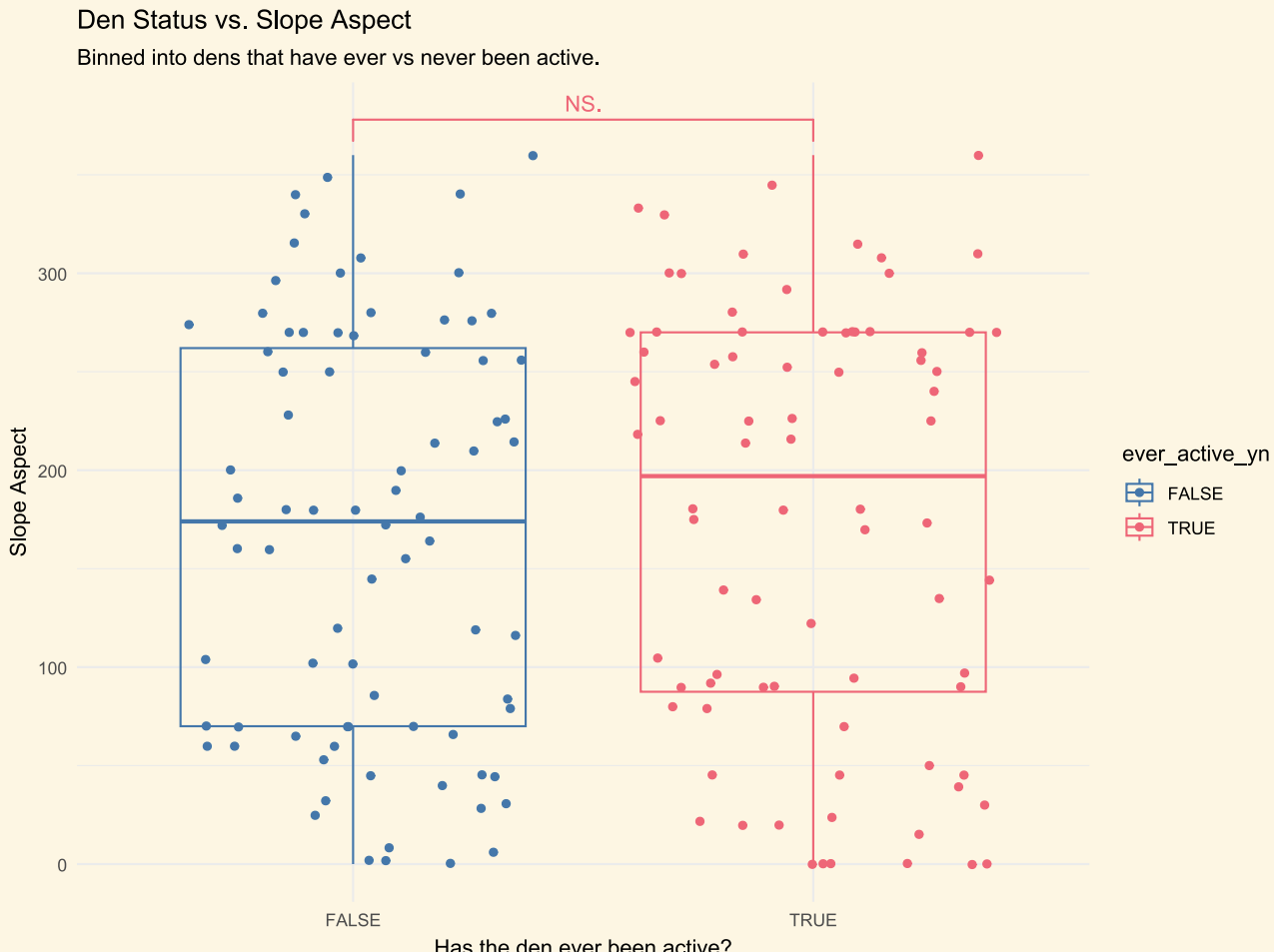
Slope grade (%)

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.



Slope aspect (degrees)

TRUE = the den has been active at least one time during the monitoring period.
FALSE = the den has never been active during the monitoring period.



Question 2

Overall, whether or not a den was ever active during the monitoring period does not appear to be significantly influenced by either den qualities (e.g. chamber width, height) or non-forestry geography (e.g., elevation, slope).

Question 3A: Does forestry condition affect windthrow probability?

Question 3B: Does windthrow severity affect den activity?

Question 3A

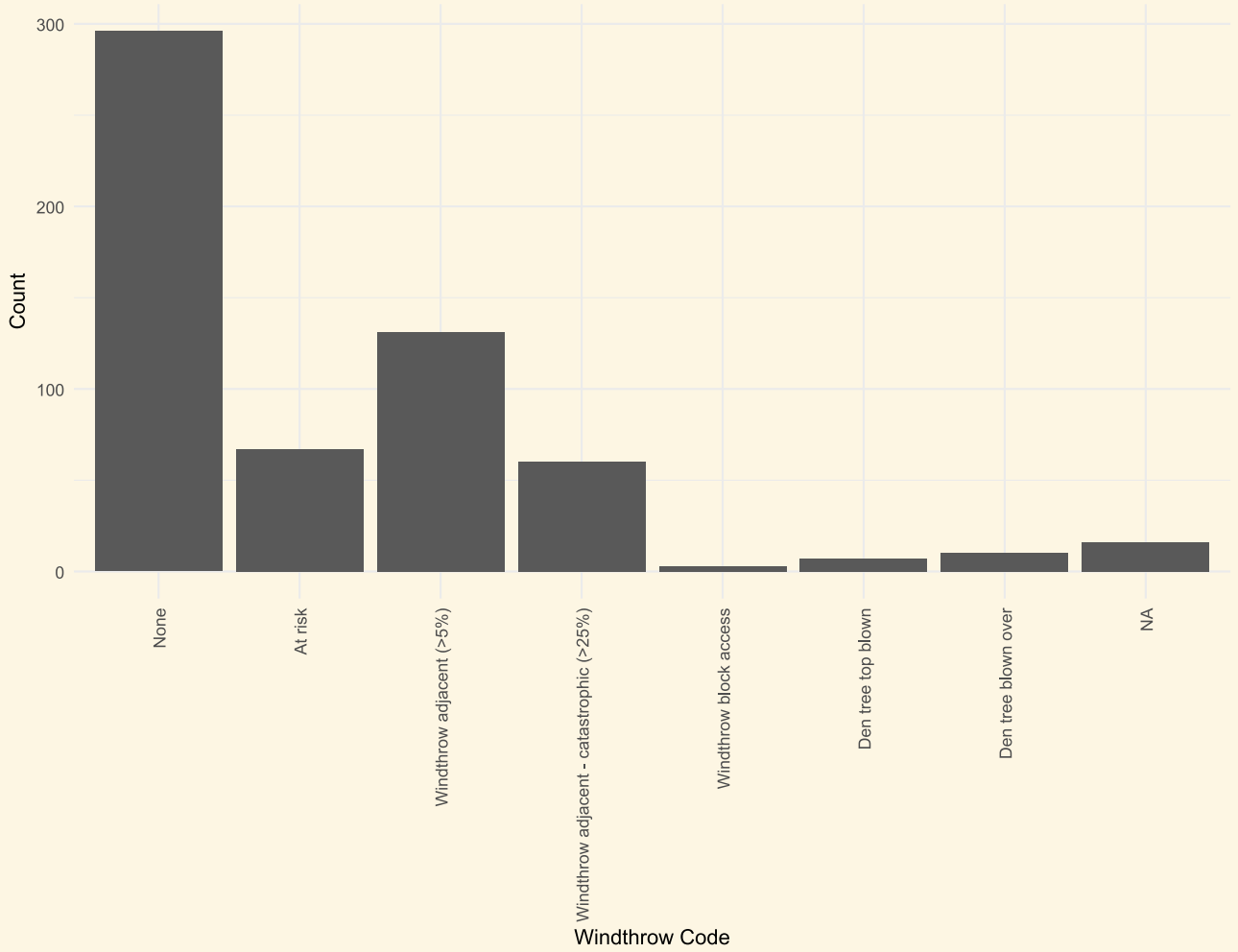
Question: How does forestry condition, such as distance from cutblock edge, retention patch size, and harvest status influence the amount of windthrow in a given area?

Question 3A

Question: How does forestry condition, such as distance from cutblock edge, retention patch size, and harvest status influence the amount of windthrow in a given area?

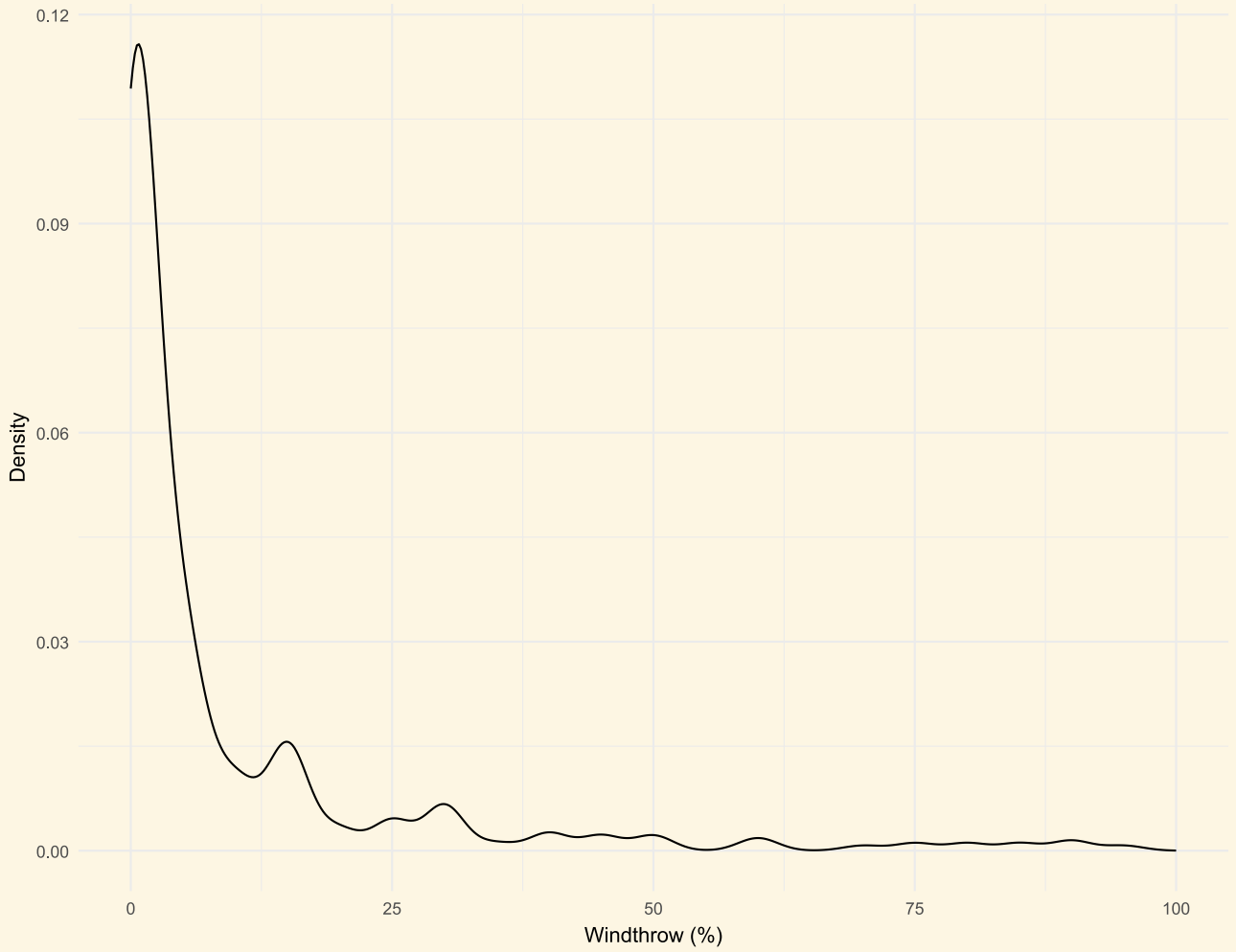
Prediction: The probability of windthrow occuring within a given area will be greater the closer to a cutblock edge that area is. Locations within smaller retention patch sizes and within 60m of harvest are more likely to have windthrow than locations in larger retention patches and futher from harvest.

Windthrow is categorized by estimating the proportion of trees within a 60m radius of a given point (lat, lon of a den) that are windthrown.

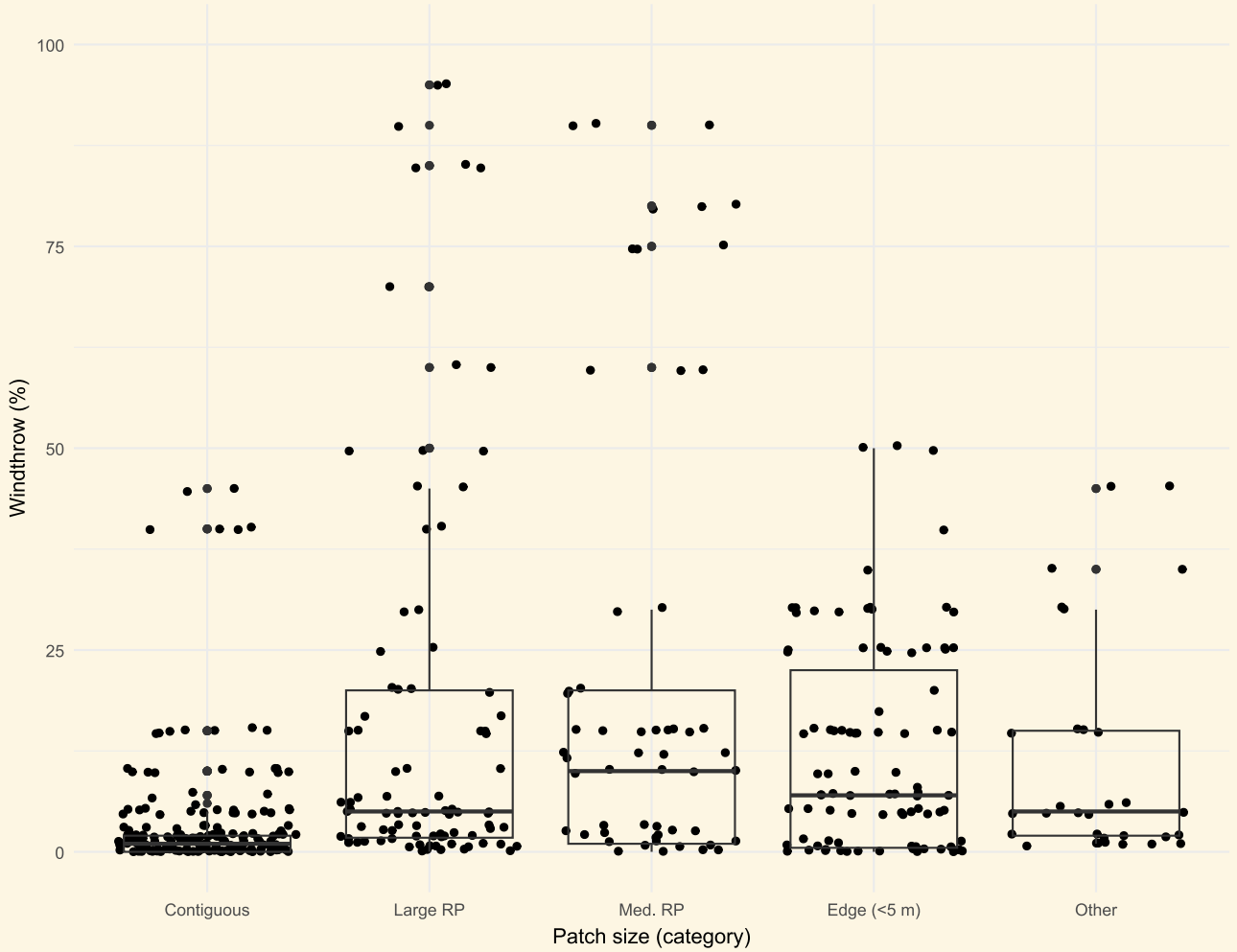


Windthrow is categorized by estimating the proportion of trees within a 60m radius of a given point (lat, lon of a den) that are windthrown.

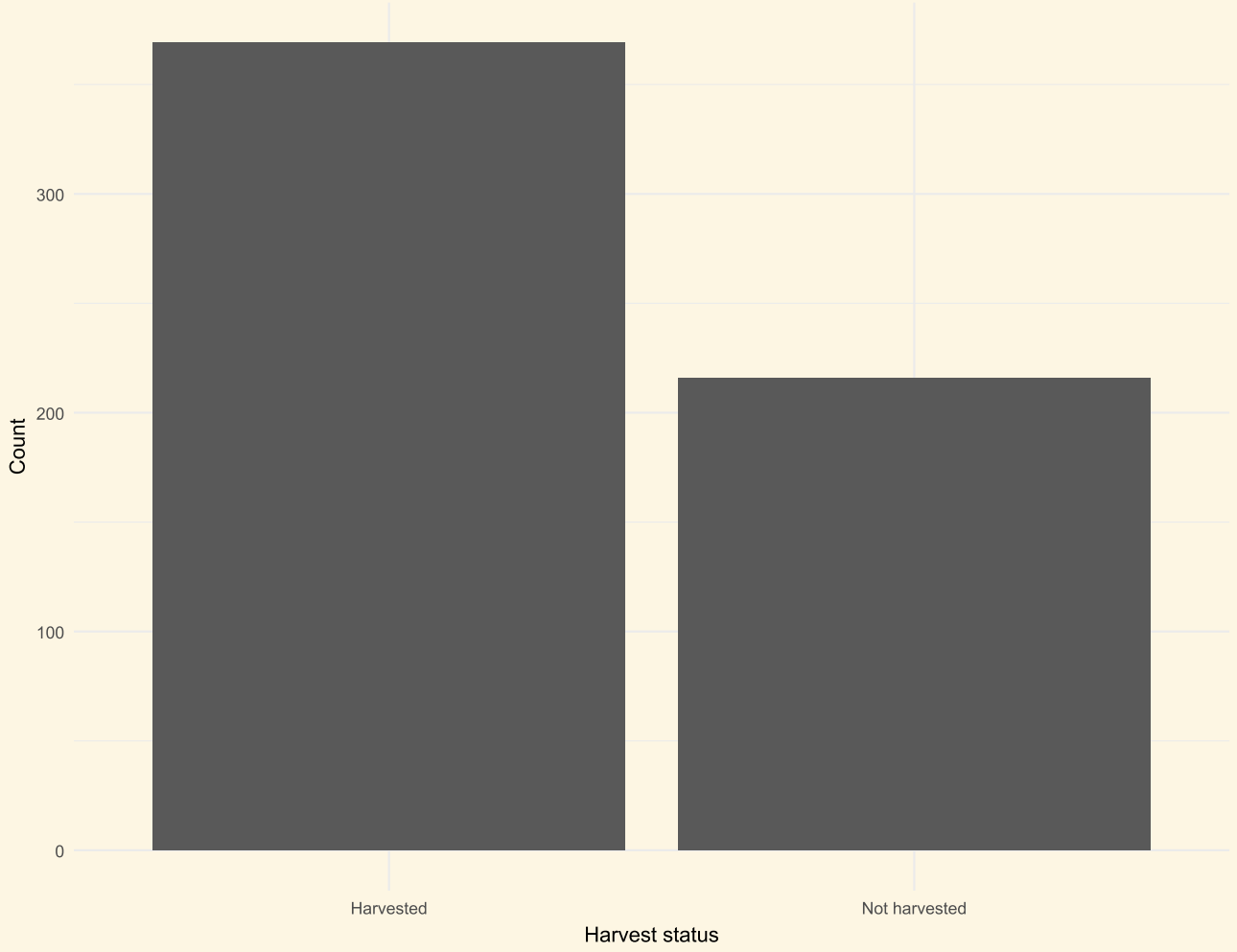
```
## Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.00 0.00 2.00 9.06 10.00 95.00 7
```



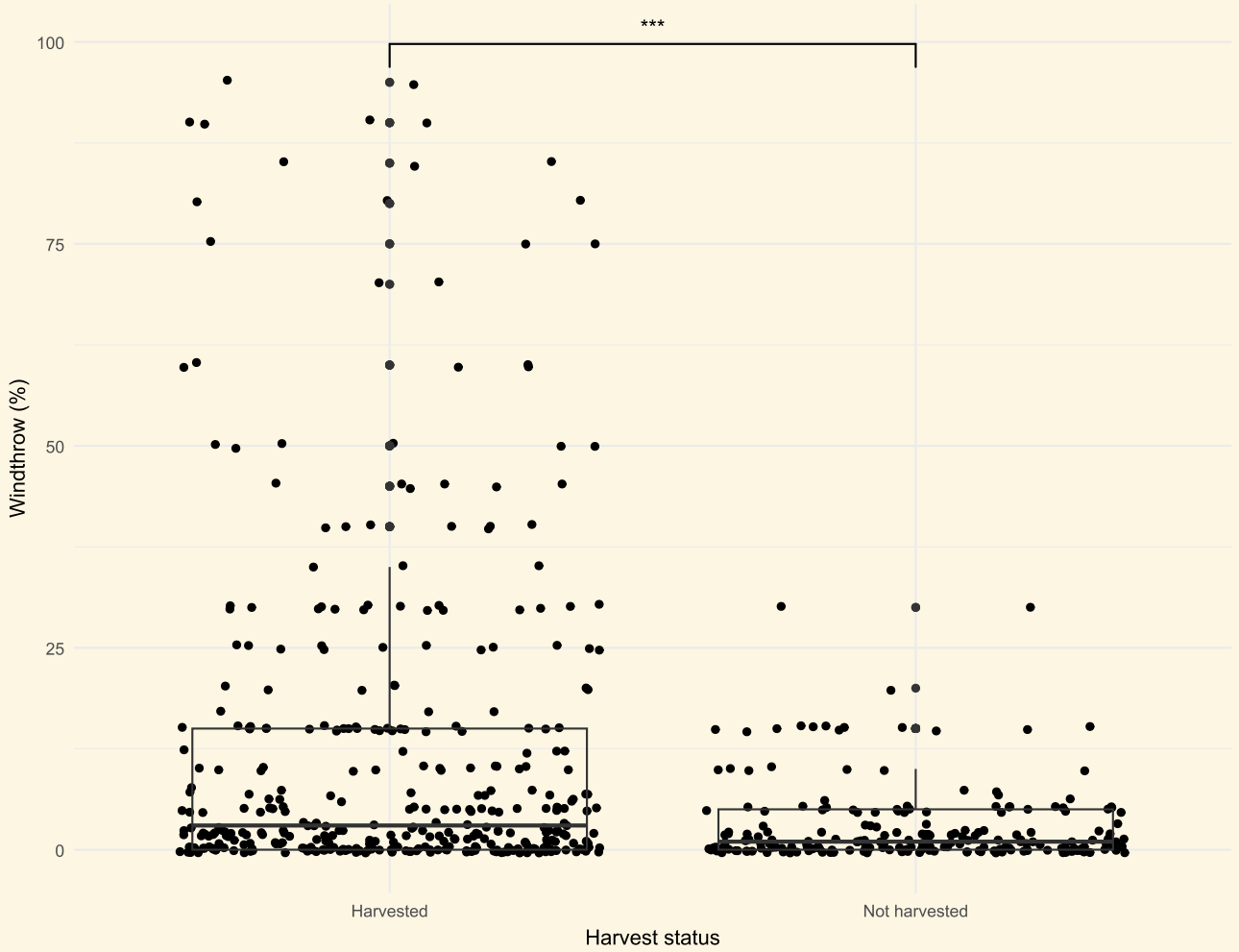
Windthrow is categorized by estimating the proportion of trees within a 60m radius of a given point (lat, lon of a den) that are windthrown.



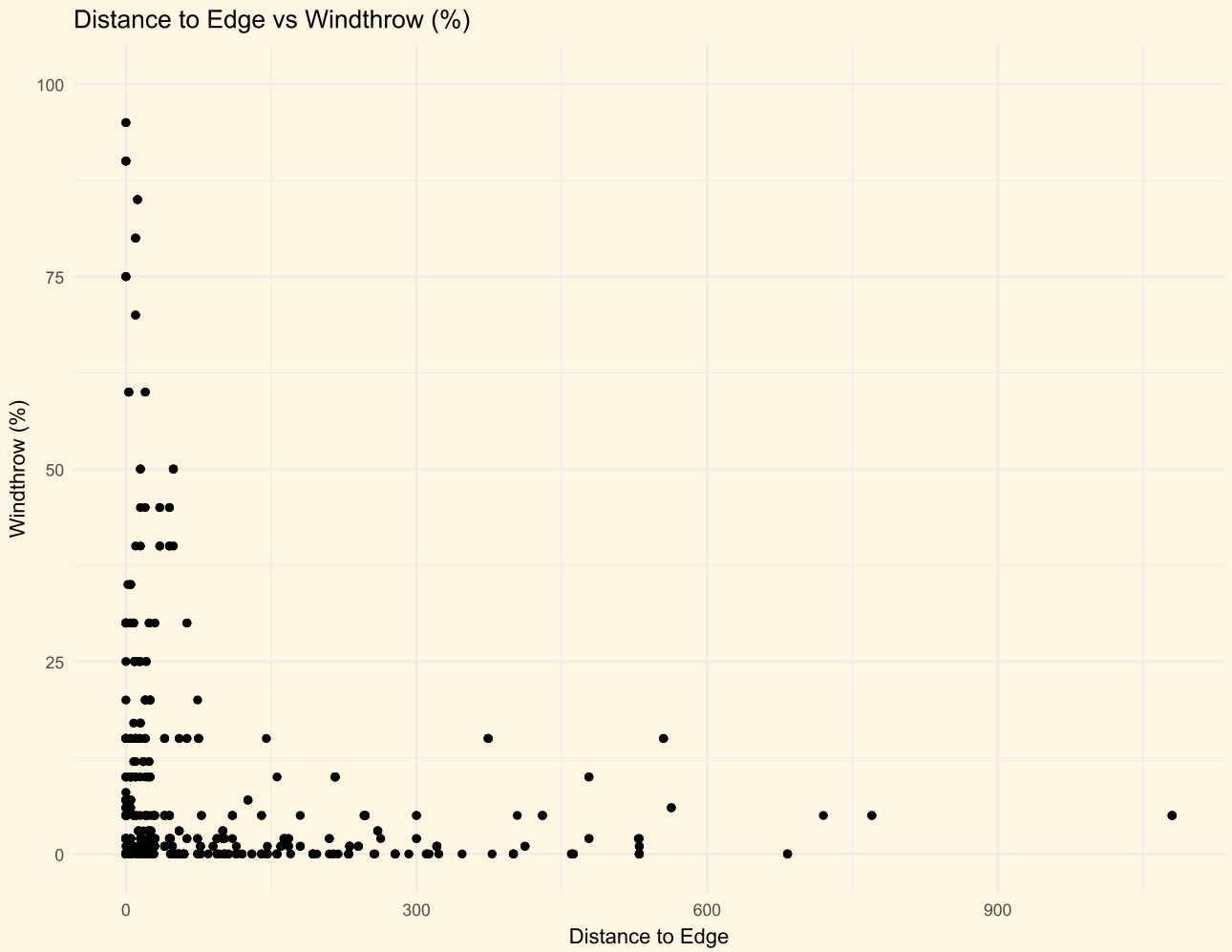
Harvest status is determined by the % tree coverage within 60m of a given point. If a road cuts through the forest OR there is forest <40 years old within 60m of that point, it counts as "harvested". Areas within 60m naturally unforested areas, such as the edge of a lake, would NOT count as "harvested" under these critera.

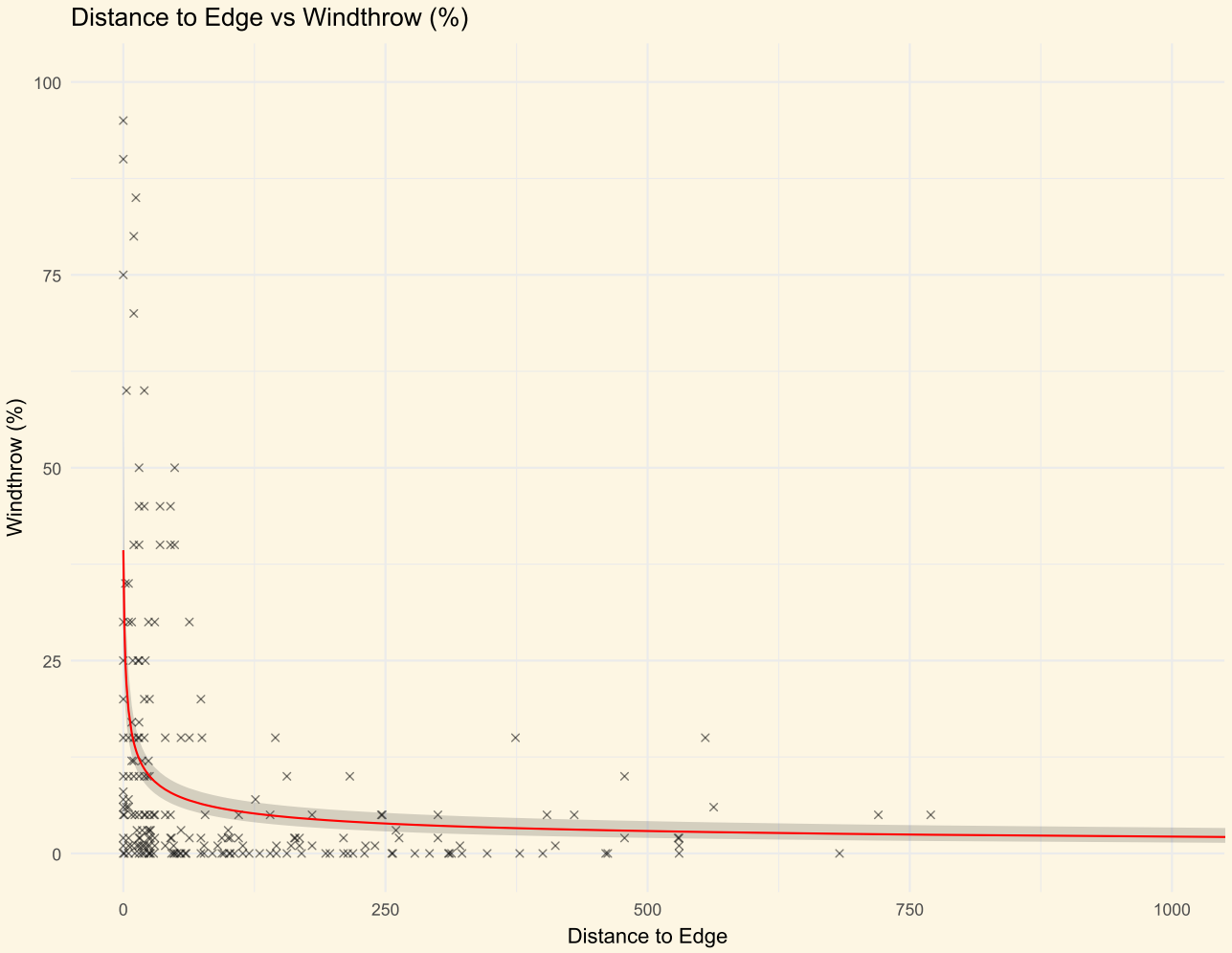


Harvested areas have significantly higher % windthrow.



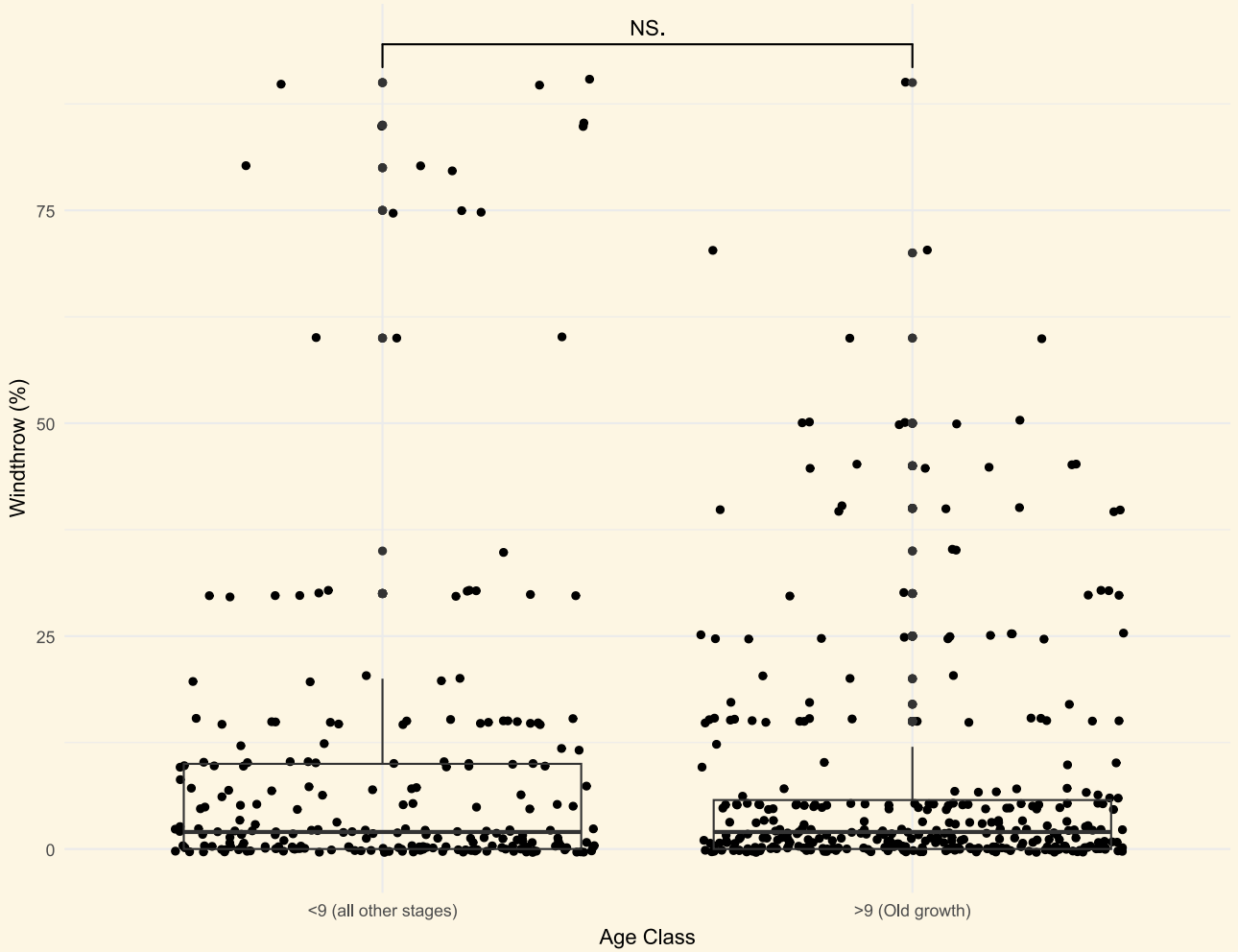
Distance to edge is the distance to any hard forest edge caused by harvest activity, including distance to <40 yo forest or distance to road (whichever was closer).



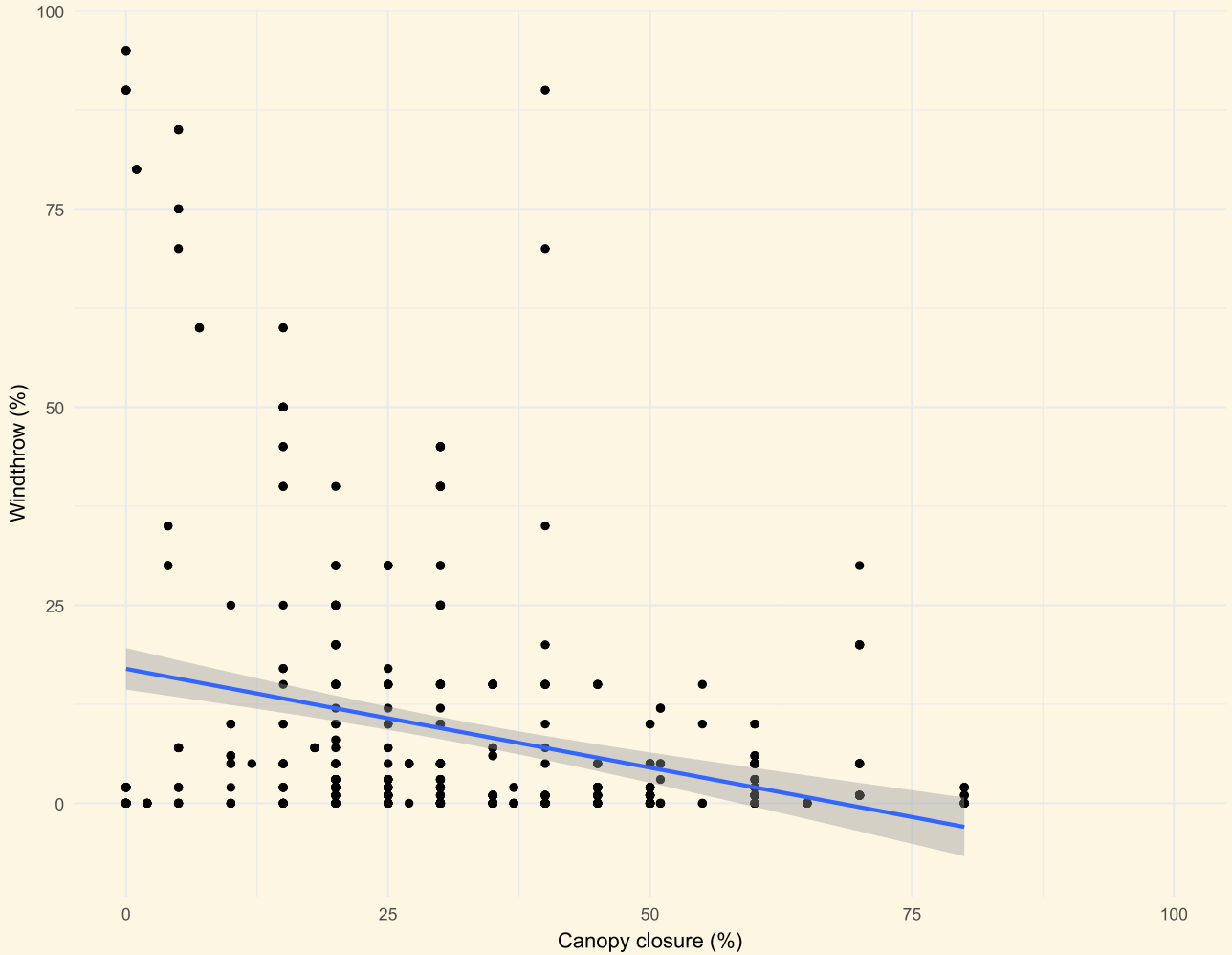

Distance to Edge vs Windthrow (%)
Windthrow (%)
100
75
50
25
0
0
250
500
750
1000
Distance to Edge

```
## Family: tweedie ( log )
## Formula: windthrow_prct ~ dist_to_edge
## Data: dat
##
## AIC BIC logLik deviance df.resid
## 1321.1 1334.5 -656.6 1313.1 205
##
##
## Dispersion parameter for tweedie family (): 4.43
##
## Conditional model:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) 3.67144 0.19578 18.753 <2e-16 ***
## dist_to_edge -0.41915 0.05416 -7.739 1e-14 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

While there is a relationship between windthrow % and distance to edge, there appears to be no relationship between forest stand age class and windthrow (there were no significant differences between finer groupings of age class, either).



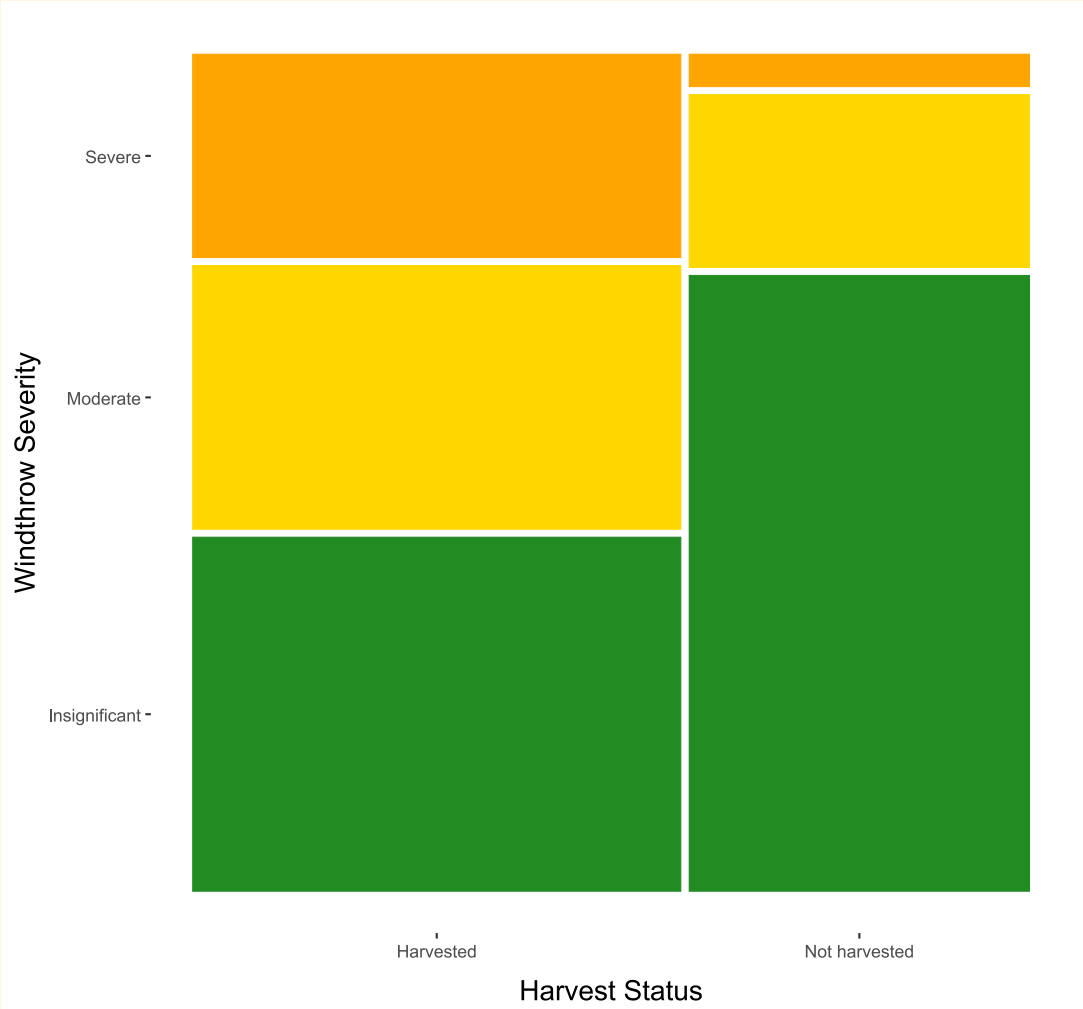
There is a significant relationship between canopy closure and windthrow.



There is a significant relationship between canopy closure and windthrow.

```
##
## Call:
## lm(formula = windthrow_prct ~ canopy_closure, data = f_full)
##
## Residuals:
## Min 1Q Median 3Q Max
## -16.959 -8.971 -4.495 2.998 83.012
##
## Coefficients:
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 16.95924 1.33669 12.688 < 2e-16 ***
## canopy_closure -0.24929 0.03602 -6.921 1.24e-11 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.77 on 553 degrees of freedom
## (35 observations deleted due to missingness)
## Multiple R-squared: 0.07972, Adjusted R-squared: 0.07805
## F-statistic: 47.9 on 1 and 553 DF, p-value: 1.245e-11
```

If there has been harvest activity within 60m of a location, windthrow severity goes up (X-squared p-value < 0.0001).




```
## X-squared
## 22.05526
```

Question 3B

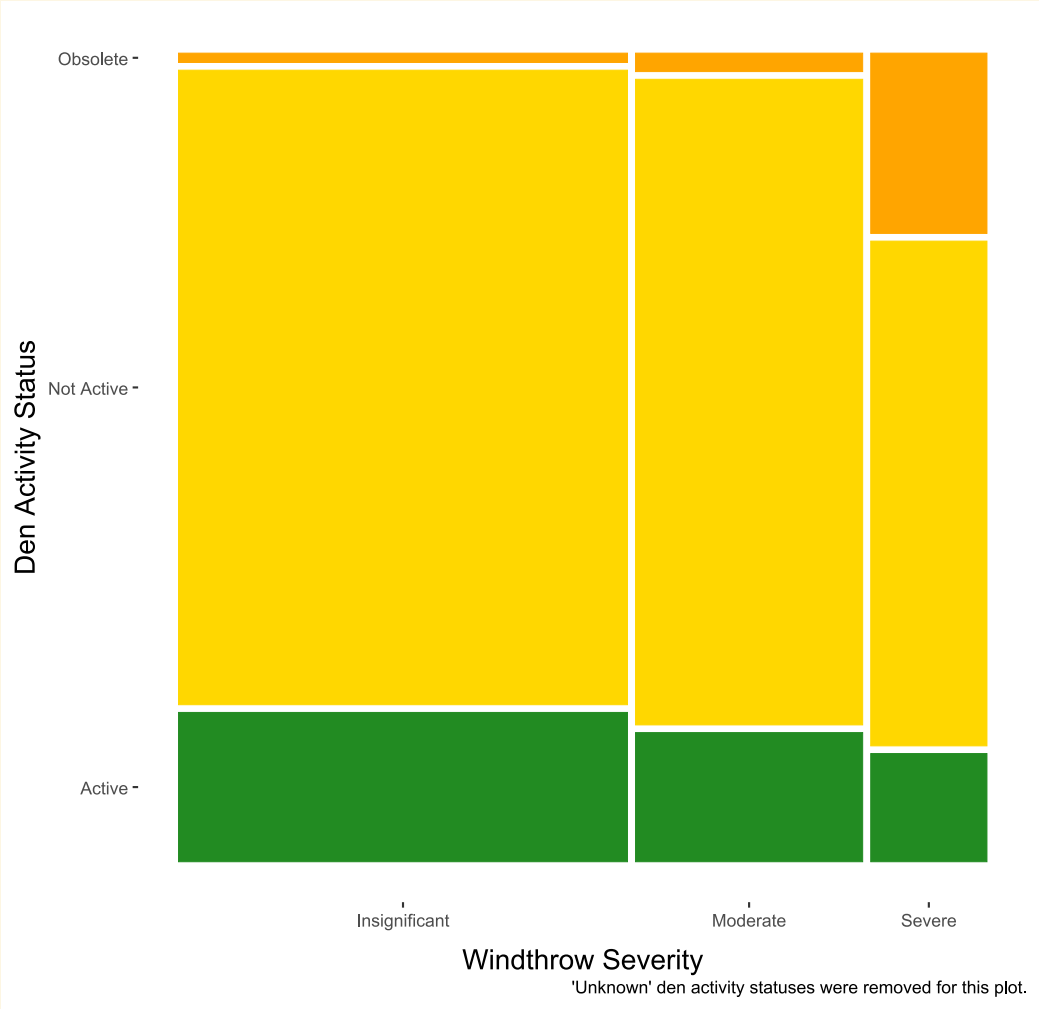
Question: How does windthrow severity influence den activity?

Question 3B

Question: How does windthrow severity influence den activity?

Prediction: Dens within areas of higher windthrow severity are less likely to be active.

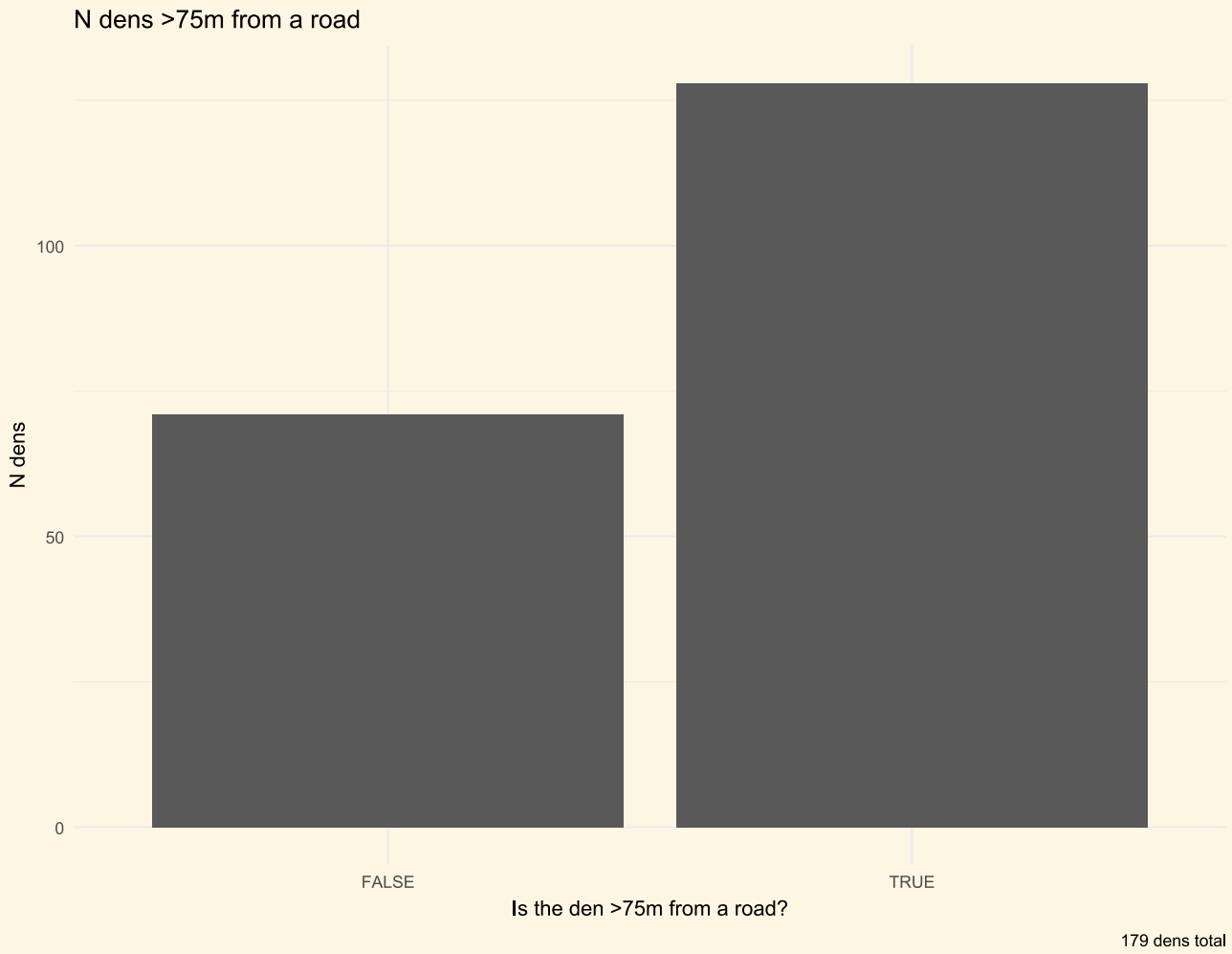
This question unfortunately is not so straightforward to answer. There does not seem to be a large difference in activity between still-functional den trees in severe vs. unaffected areas. In general, regardless of windthrow state, dens just aren't active very much.



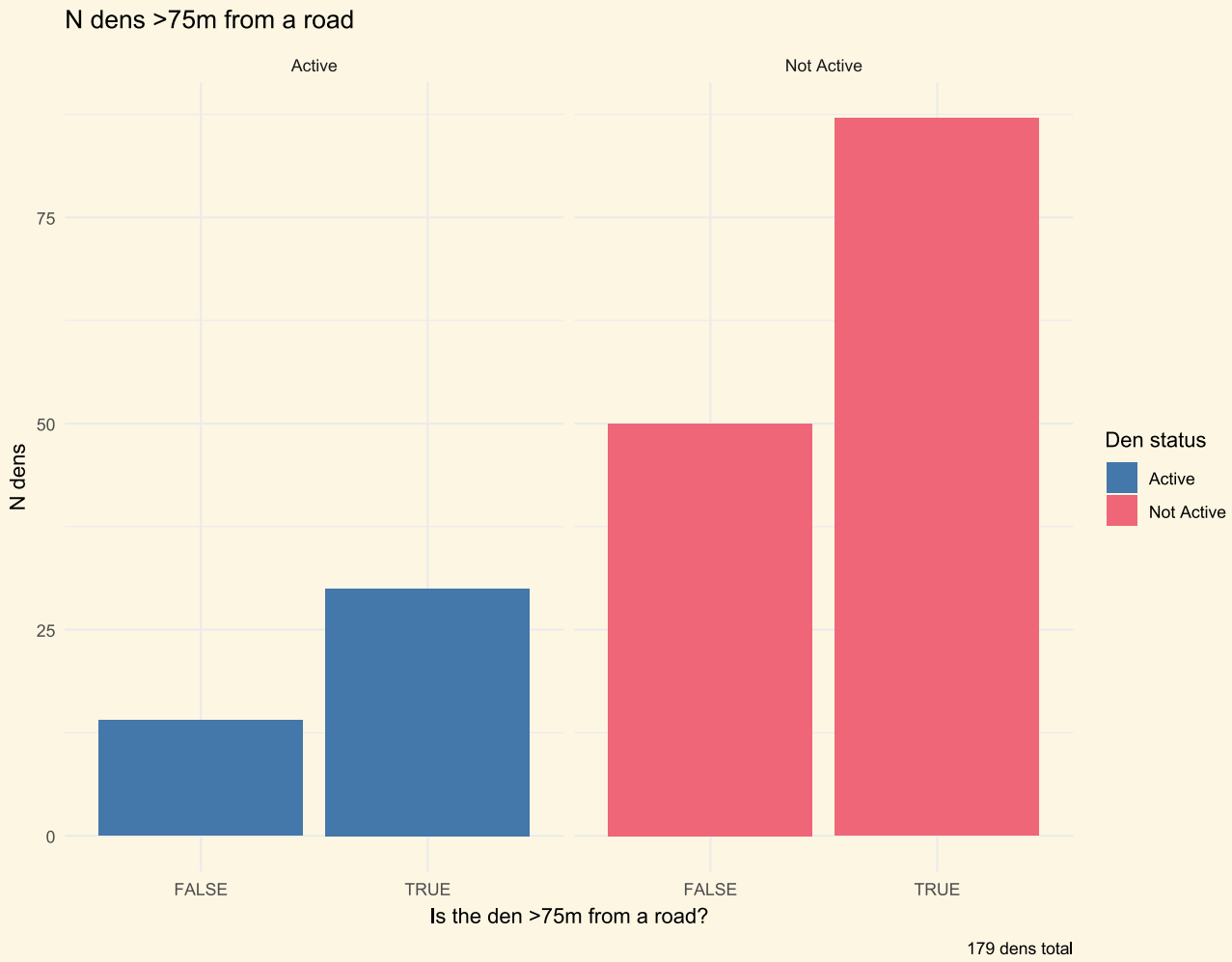
Question 4: Does current management align with recommendations?

How many dens fall within best practice guidelines?

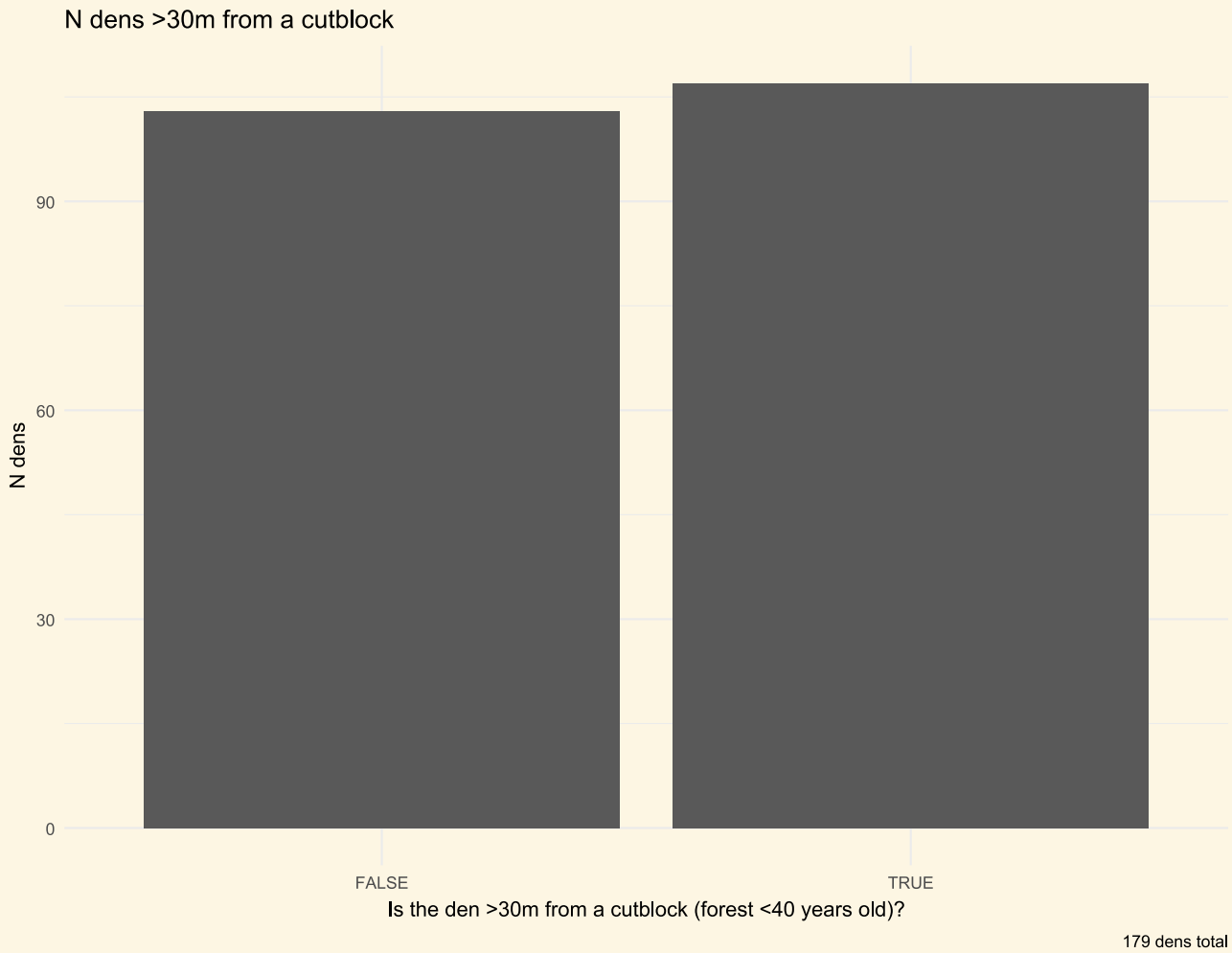
Dens >75m from the nearest road



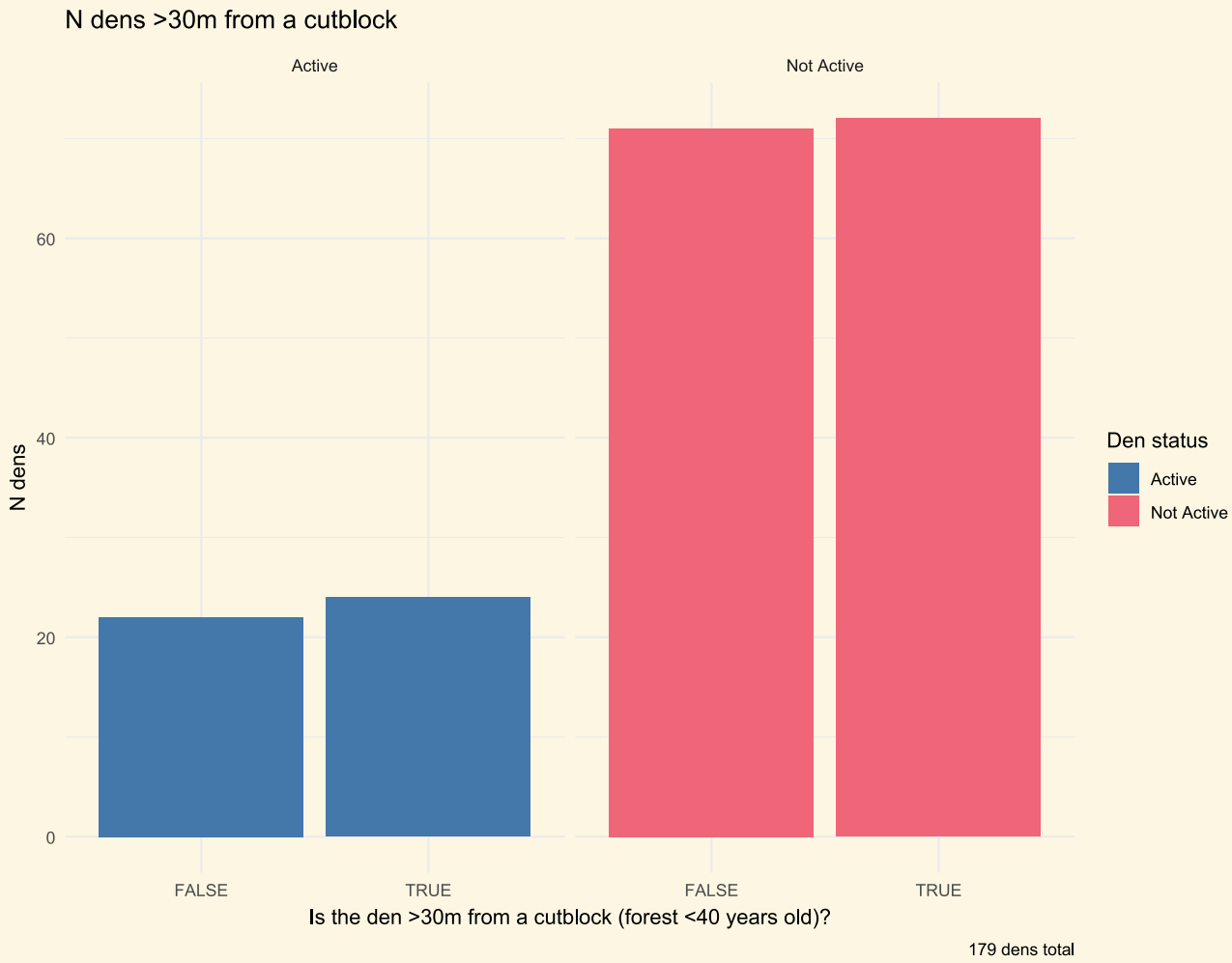
Dens >75m from the nearest road



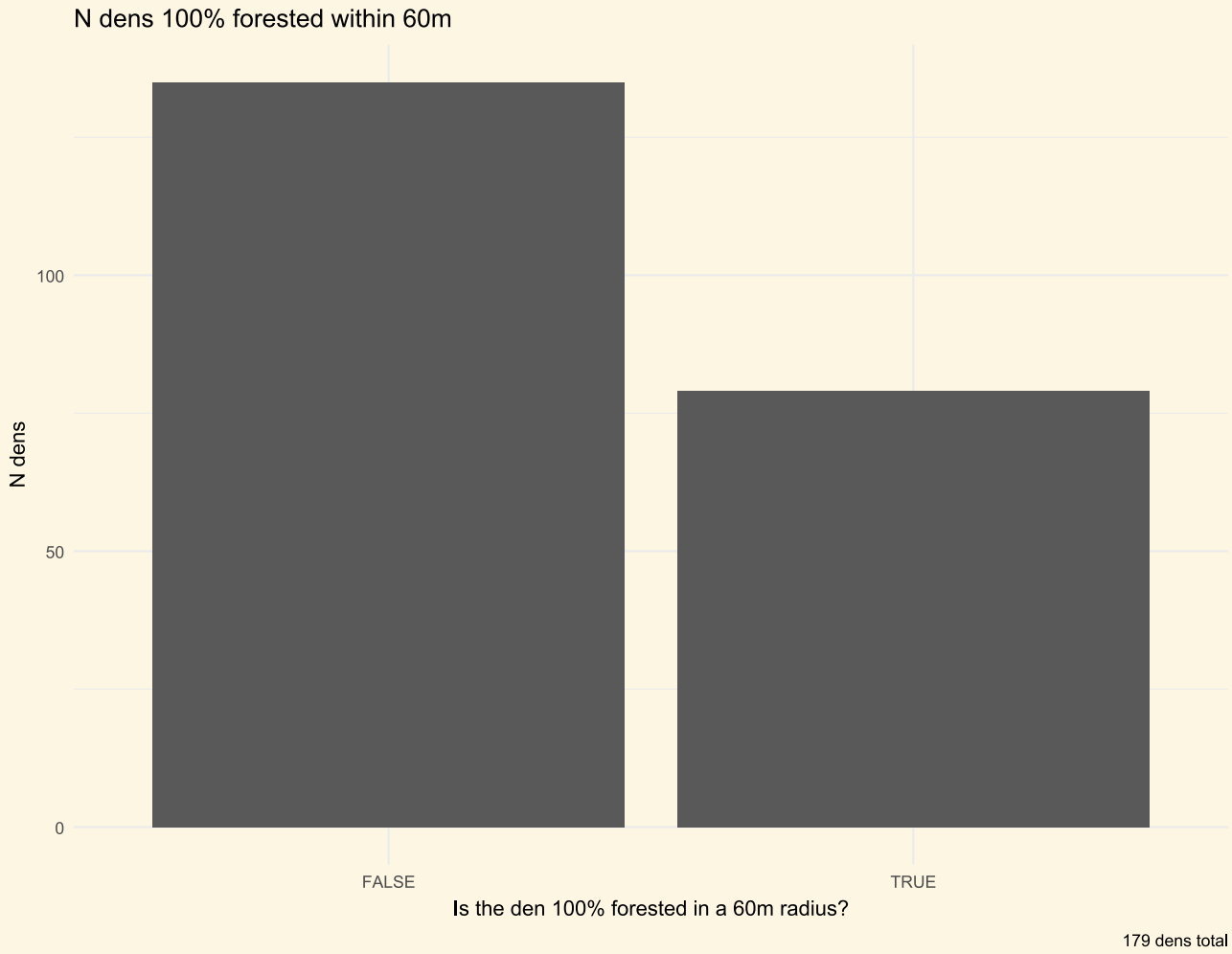
Dens >30m from cutblock/new growth



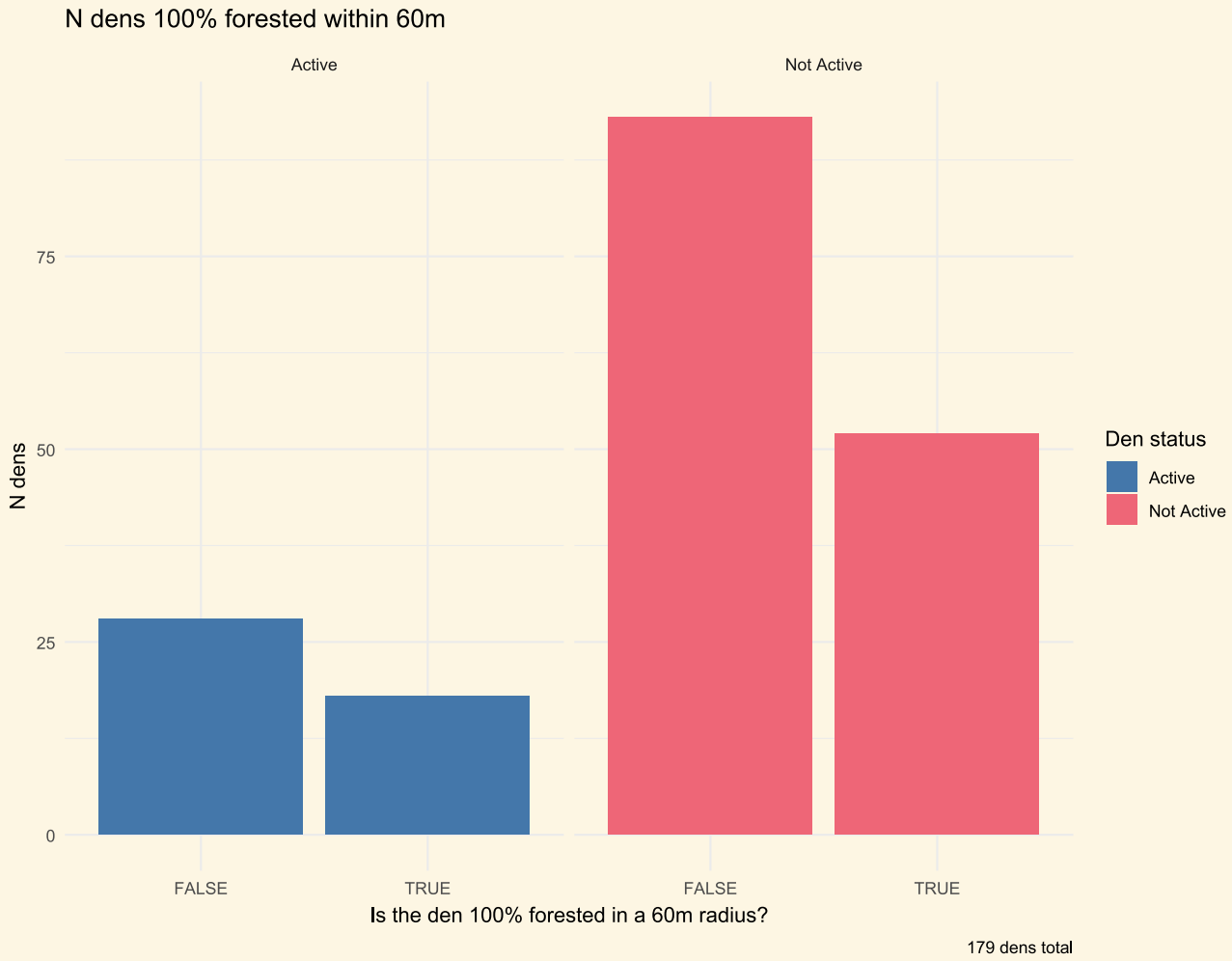
Dens >30m from cutblock/new growth



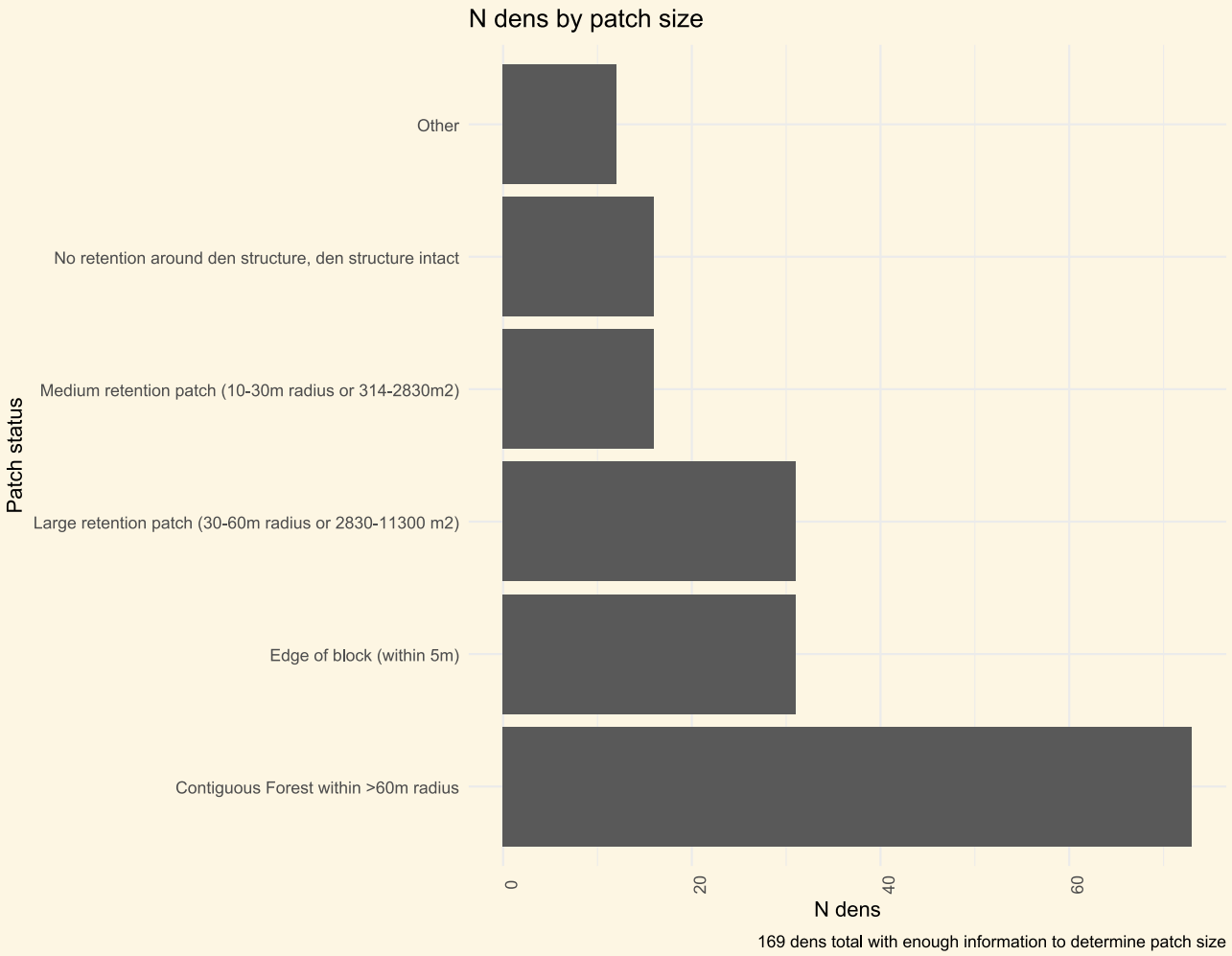
Dens with 100% forest retention in a 60m radius



Dens with 100% forest retention in a 60m radius



Dens within each patch size class



Dens within each patch size class