Analysis of invasion times

Data are time series of single site invasions from 30 randomly selected locations (same 30 sites for each parameter combination).

Load some libraries

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

Navigate to folder and read the data.

```
setwd('~/Documents/code/working/wasps/output/')
wasps.invasion <- read.csv("wasps INVASION-EXPERIMENT-table.csv", skip=6)
```

Select only variables we need.

```
wasps.sel <- select(wasps.invasion, 1:2 ,11, 15, 21:23)
```

Time series plots

Panel plot of time series, lines coloured by intrinsic growth-rate `r.mean`, panels arranged by local mean dispersal distance `lambda.1` and probability of long distance dispersal `p.ldd`.

```
ggplot(wasps.sel, aes(x=X.step., y=prop.occupied, color=as.factor(r.mean))) +
  geom_line(aes(group=X.run.number.), lwd=.35, alpha=0.5) +
  xlim(0, 150) + ylim(0, 1) +
  labs(x='Time, years', y='Proportion of land occupied') +
  scale_color_viridis_d(option='D') +
  facet_grid(p.ldd ~ lambda.1, labeller=label_both, as.table=FALSE)
```
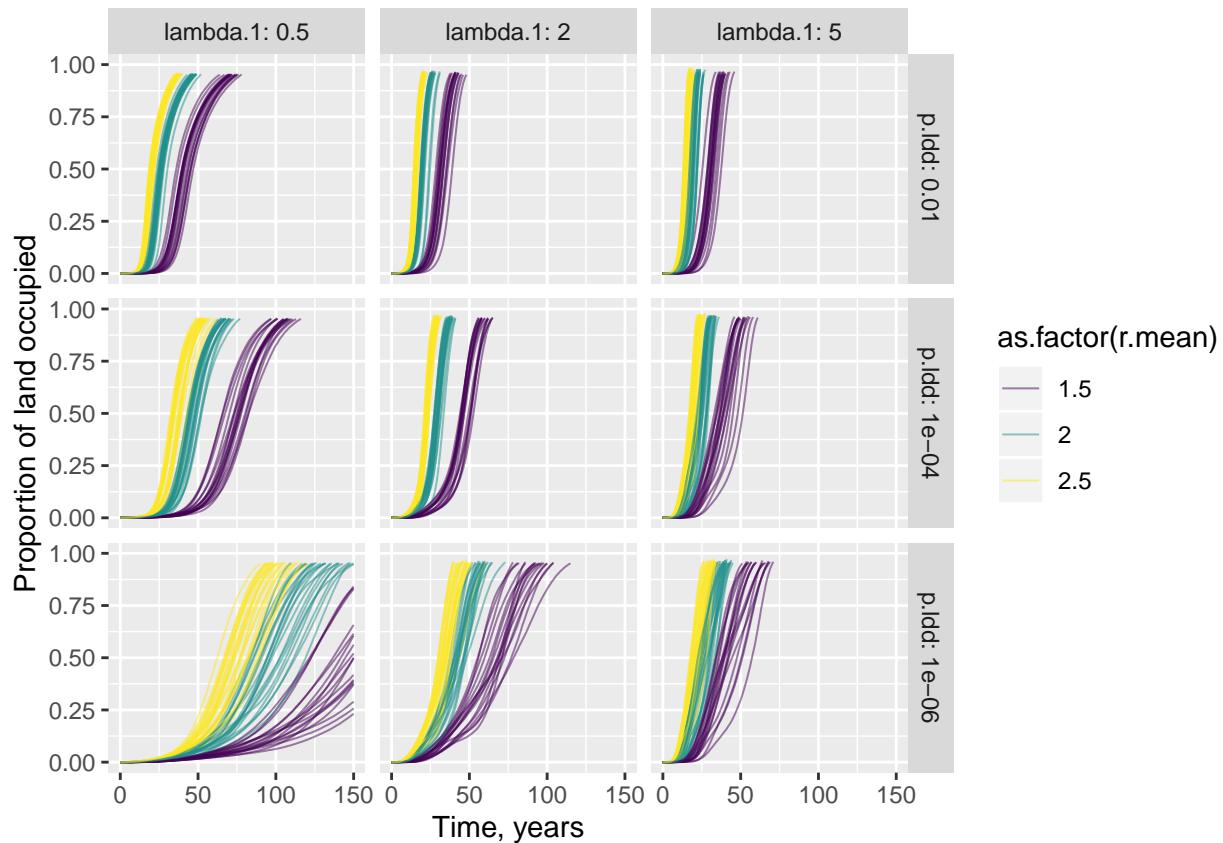
Trends in time to 95% occupancy

Determine times taken to 95% occupancy. These will be the last time step in each case, when `prop.occupied` >=0.95 at that time, since experiment runs used this as stopping criterion.

```
wasps.t <- wasps.sel %>%
  group_by(X.run.number., r.mean) %>%
  summarise_at('X.step.', max) %>%
  merge(wasps.invasion) %>%
  filter(prop.occupied >= 0.95)
```

And plot it

```
ggplot(wasps.t, aes(x=lambda.1, y=X.step.)) +
  geom_jitter(aes(color=as.factor(p.ldd)), width=.05, height=0) +
  scale_color_viridis_d(option='C', direction=-1) +
  facet_wrap(vars(r.mean), nrow=1, labeller=label_both) +
  labs(y='Time to 95% occupied', x='Local mean dispersal distance, km')
```
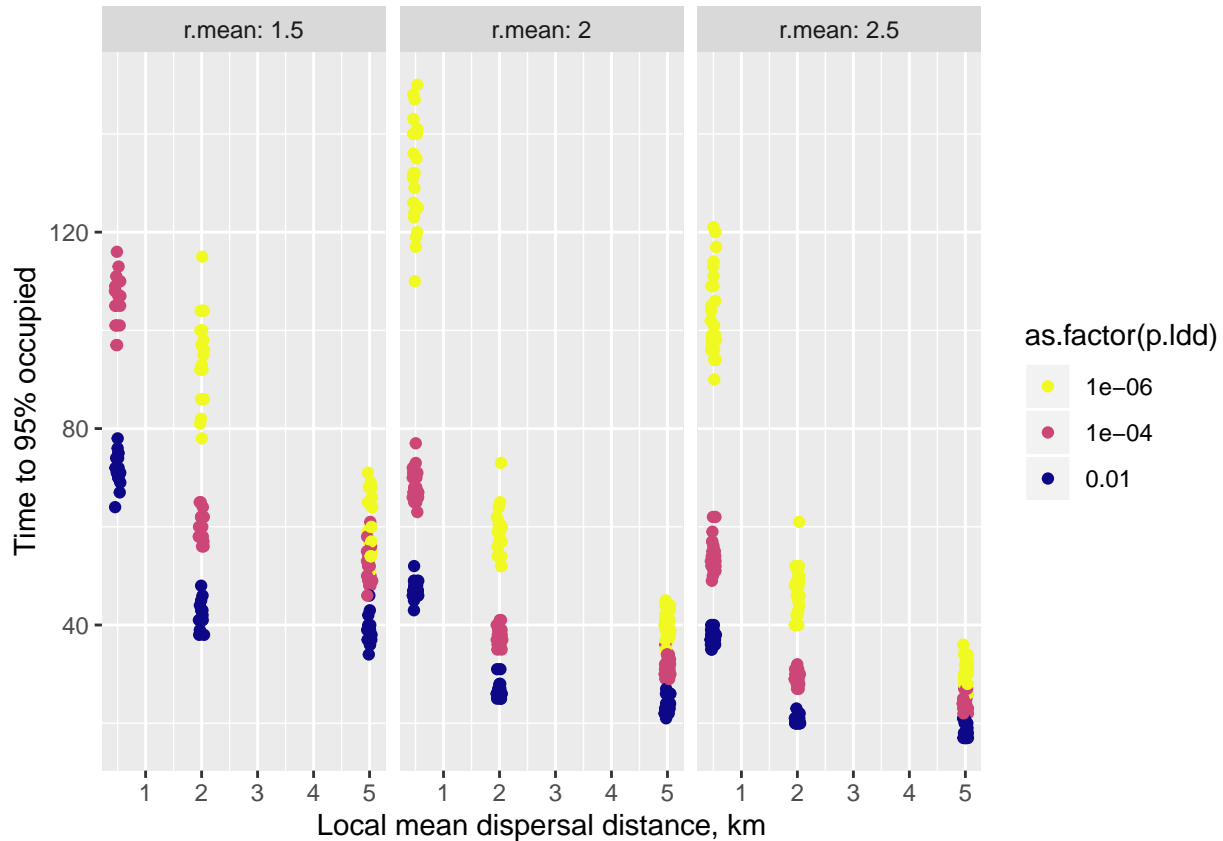
Need more data to fit curves

To fit curves to these data we need more values of `lambda.1` than $\{0.5, 2, 5\}$ to avoid warnings about near-singularities with the default Loess fitting, and also unlikely 'kinks' in the curves. A linear model is clearly not appropriate per the plots. See below:

```
ggplot(wasps.t, aes(x=lambda.1, y=X.step., colour=as.factor(p.ldd))) +
  geom_smooth(aes(group=p.ldd), colour='blue') +
  geom_smooth(aes(group=p.ldd), colour='gray', method='lm') +
  geom_point(size=0.5) +
  scale_colour_viridis_d(option='C', direction=-1) +
  facet_wrap(vars(r.mean), nrow=1, labeller=label_both) +
  labs(y='Time to 95% occupied', x='Local mean dispersal distance, km')
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : pseudoinverse used at 1.985
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : neighborhood radius 3.015
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : reciprocal condition number 0
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : There are other near singularities as well. 9.0902
```

```
## Warning in predLoess(object$y, object$x, newx = if
```

```
## (is.null(newdata)) object$x else if (is.data.frame(newdata))
## as.matrix(model.frame(delete.response(terms(object)), : pseudoinverse used at
## 1.985

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## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : pseudoinverse used at 0.4775

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : neighborhood radius 4.5225

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : reciprocal condition number 1.1101e-16

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
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## parametric, : reciprocal condition number 1.707e-16

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## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
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```
## parametric, : reciprocal condition number 1.2133e-16

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## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
## parametric, : reciprocal condition number 1.1989e-16

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