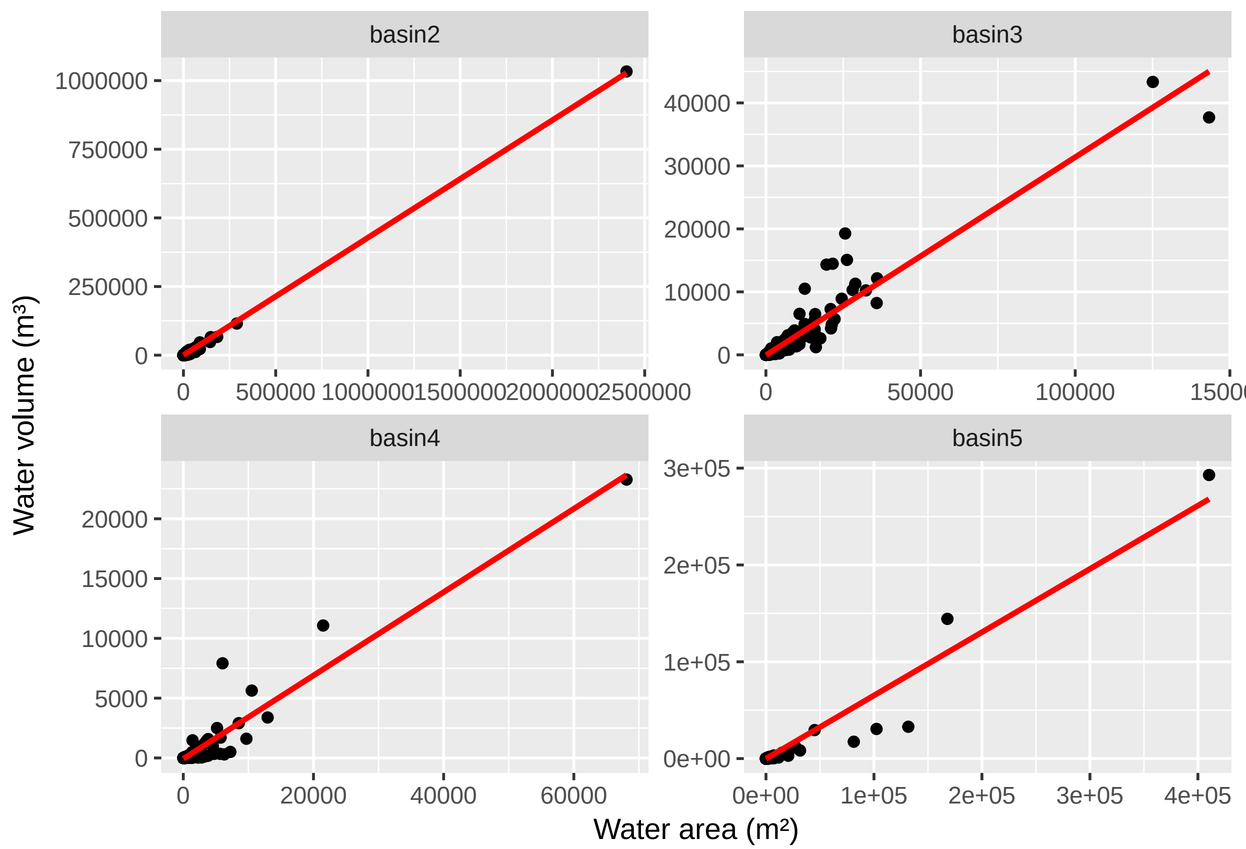
WDPM area volume scaling Notebook

Analysis of pond area-volume scaling from WDPM output for sub-basins at Camrose Creek. The sub-basins do not correspond to any other sub-basin delineation. They are simply regions which were determined by WDPm to drain to a common point. The pond volumes and areas were extracted from the WDPM files using the R function `WDPM_volume_area_scaling()`

Plot pond volumes vs areas

```
graphFile <- "WDPM_areas_vols.png"
outfile <- "./"
infile <- "./WDPM_water_patches.csv"
all <- read.csv(infile, stringsAsFactors = FALSE, header = TRUE)

p <- ggplot(all, aes(area, volume)) +
  geom_point() + xlab("Water area (m²)") +
  ylab("Water volume (m³)") +
  facet_wrap(~basin, ncol = 2, scales = "free") +
  geom_smooth(method = "lm", se = FALSE, colour = "red")
print(p)
```



Fit linear regressions to points

```
all_basins <- unique(all$basin)
num_basins <- length(all_basins)
fit <- c(0)
for (i in 1:num_basins) {
  basin <- all[all$basin == all_basins[i],]
```

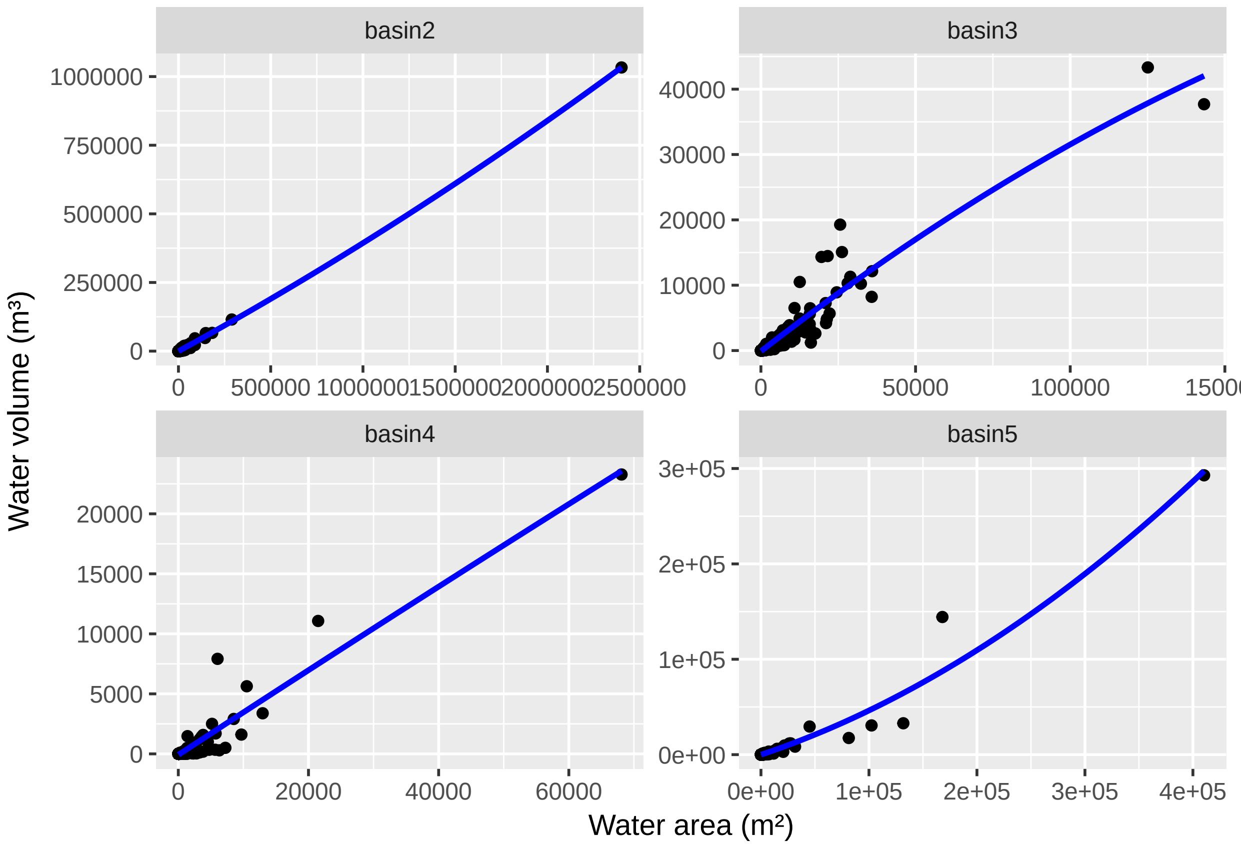
```r
  # do lm
  fit <- lm(volume~area, basin)
  cat("basin:", all_basins[i],"\n")
  pander(summary(fit))
}
```

```
## basin: basin3
##
## ---------------------------------------------------------------
##               Estimate   Std. Error   t value   Pr(>|t|)
## ----------------- ---------- ------------ --------- -----------
##  **(Intercept)**    -61.1       12.66      -4.825    1.513e-06
##
##     **area**        0.3144     0.002402     130.9        0
## ---------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      1860              537.2          0.9022       0.9021
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area
##
## basin: basin4
##
## ---------------------------------------------------------------
##               Estimate   Std. Error   t value   Pr(>|t|)
## ----------------- ---------- ------------ --------- -----------
##  **(Intercept)**    -74.16      18.47      -4.016    6.836e-05
##
##     **area**        0.3485     0.005305     65.7     8.6e-248
## ---------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      501               405.3          0.8964       0.8962
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area
##
## basin: basin5
##
## ---------------------------------------------------------------
##               Estimate   Std. Error   t value   Pr(>|t|)
## ----------------- ---------- ------------ --------- -----------
##  **(Intercept)**    -159.1      22.74      -6.995    3.096e-12
##
##     **area**        0.6535     0.002935     222.6        0
## ---------------------------------------------------------------
##
```

```
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      4002               1435          0.9253       0.9253
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area
##
## basin: basin2
##
## ---------------------------------------------------------------
##               Estimate   Std. Error   t value   Pr(>|t|)
## ----------------- ---------- ------------ --------- -----------
##  **(Intercept)**    -70.45      3.417      -20.62    4.026e-93
##
##     **area**        0.4281    0.0001694     2527         0
## ---------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##     14753              414.9          0.9977       0.9977
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area
```

Plot with second order polynomial

```
p <- ggplot(all, aes(area, volume)) +
  geom_point() + xlab("Water area (m²)") +
  ylab("Water volume (m³)") +
  facet_wrap(~basin, ncol = 2, scales = "free") +
  geom_smooth(method = "lm", formula = y~x+I(x^2), se = FALSE, colour = "blue")
print(p)
```



Fit second order polynomial

```r
all_basins <- unique(all$basin)
num_basins <- length(all_basins)
fit <- c(0)
for (i in 1:num_basins) {
  basin <- all[all$basin == all_basins[i],]
  fit <- lm(volume~area+I(area^2), basin)
  cat("basin:", all_basins[i],"\n")
  pander(summary(fit))
}
```

```
## basin: basin3
##
## -----------------------------------------------------------------
##                  Estimate    Std. Error   t value   Pr(>|t|)
## ----------------- ------------ ------------ --------- -----------
##  **(Intercept)**     -97.46       12.63       -7.719   1.903e-14
##
##     **area**         0.3679      0.005162     71.27        0
##
##   **I(area^2)**    -5.156e-07   4.447e-08    -11.59    4.66e-30
## -----------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
```

```
##      1860              518.9          0.9088       0.9087
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area + I(area^2)
##
## basin: basin4
##
## -----------------------------------------------------------------
##                Estimate    Std. Error   t value   Pr(>|t|)
## ----------------- ------------ ------------ --------- -----------
##  **(Intercept)**     -76.98       19.42      -3.963    8.482e-05
##
##     **area**         0.3545      0.01381      25.66    3.547e-93
##
##   **I(area^2)**    -1.068e-07   2.265e-07    -0.4714    0.6375
## -----------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      501              405.6          0.8964       0.896
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area + I(area^2)
##
## basin: basin5
##
## ----------------------------------------------------------------
##               Estimate    Std. Error   t value   Pr(>|t|)
## ----------------- ----------- ------------ --------- -----------
##  **(Intercept)**    -65.66       18.19      -3.611    0.0003089
##
##     **area**         0.379      0.006151     61.61        0
##
##   **I(area^2)**    8.434e-07   1.748e-08     48.24        0
## ----------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      4002              1141          0.9528       0.9528
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area + I(area^2)
##
## basin: basin2
##
## ----------------------------------------------------------------
##               Estimate    Std. Error   t value   Pr(>|t|)
## ----------------- ----------- ------------ --------- -----------
##  **(Intercept)**    -50.62       2.868      -17.65    5.042e-69
##
```

```
##     **area**        0.3676     0.0007714     476.6        0
##
##   **I(area^2)**    2.611e-08   3.276e-10     79.71        0
## ----------------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##     14753               346.9          0.9984       0.9984
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area + I(area^2)
```

Value of r^2 is not greatly improved by using second-order polynomial, and there is still a large negative intercept. Therefore, refit without intercept.

```
all_basins <- unique(all$basin)
num_basins <- length(all_basins)
fit <- c(0)
for (i in 1:num_basins) {
  basin <- all[all$basin == all_basins[i],]
  # do lm
  fit <- lm(volume~area-1, basin)
  cat("basin:", all_basins[i],"\n")
  pander(summary(fit))
}
```

```
## basin: basin3
##
## -------------------------------------------------------
##         Estimate   Std. Error   t value   Pr(>|t|)
## ---------- ---------- ------------ --------- ----------
##  **area**    0.3124     0.002377     131.4       0
## -------------------------------------------------------
##
##
## --------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      1860              540.4          0.9028       0.9028
## --------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area - 1
##
## basin: basin4
##
## ---------------------------------------------------------
##         Estimate   Std. Error   t value    Pr(>|t|)
## ---------- ---------- ------------ --------- ------------
##  **area**    0.3443     0.00528      65.22    1.141e-246
## ---------------------------------------------------------
##
##
## --------------------------------------------------------------
```

```
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      501               411.4          0.8948       0.8946
## ---------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area - 1
##
## basin: basin5
##
## ------------------------------------------------------
##         Estimate   Std. Error   t value   Pr(>|t|)
## ---------- ---------- ------------ --------- ----------
##  **area**    0.6521     0.002946     221.4       0
## ------------------------------------------------------
##
##
## ---------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##      4002              1444           0.9245       0.9245
## ---------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area - 1
##
## basin: basin2
##
## ------------------------------------------------------
##         Estimate   Std. Error   t value   Pr(>|t|)
## ---------- ---------- ------------ --------- ----------
##  **area**    0.428     0.0001718     2492        0
## ------------------------------------------------------
##
##
## ---------------------------------------------------------------
##  Observations   Residual Std. Error   $R^2$    Adjusted $R^2$
## -------------- --------------------- -------- ----------------
##     14753              420.8          0.9976       0.9976
## ---------------------------------------------------------------
##
## Table: Fitting linear model: volume ~ area - 1
```