Untitled

June 23, 2017

In [1]:
```
import numpy as np
import pandas as pd
import sklearn
import matplotlib
%matplotlib inline
import matplotlib.pyplot as plt

from IPython.display import set_matplotlib_formats
set_matplotlib_formats('png', 'pdf')
```

In [2]:
```
r1 = pd.read_csv('tps.ISB.ratios.tab', sep=' ')
print(r1.shape)
r1.head()
```

```
(12099, 67)
```

```
/Users/dreiss/miniconda3/lib/python3.6/site-packages/IPython/core/interactiveshell.py:2683: DtypeWarning: Columns
  interactivity=interactivity, compiler=compiler, result=result)
```

	nrm_diel_Day1.Dk	nrm_diel_Day1.Lt	nrm_diel_Day2.Dk	nrm_diel_Day2.Lt	\
1000	-0.54922	0.58181	0.10346	0.42690	
10002	-1.24427	1.19105	-1.00189	0.86039	
10006	-0.36077	-0.04452	-0.10789	-0.09317	
10008	-1.96042	-0.57802	-0.87794	-2.17830	
10010	0.02945	-1.14524	-0.97718	1.06226	

	nrm_diel_Day3.Dk	nrm_diel_Day3.Lt	nrm_diel_Day4.Dk	nrm_diel_Day4.Lt	\
1000	0.39565	0.45545	-0.24153	-0.84529	
10002	-1.04884	0.83065	-0.83815	0.29552	
10006	0.46013	-0.13913	0.37880	-0.27903	
10008	0.93808	1.19216	1.55504	0.56126	
10010	-0.16960	-0.50967	0.59087	-0.91881	

	nrm_diel_Day5.Dk	nrm_diel_Day5.Lt	...	\
1000	-0.39492	0.42528	...	
10002	0.30941	1.45448	...	
10006	0.58274	0.20985	...	
10008	2.55721	2.44418	...	
10010	-0.33980	3.03597	...	

	nrmlight.B.nrm.exp.3	nrmlight.B.nrm.sta.1	nrmlight.B.nrm.sta.2	\
1000	-0.02569	-0.60172	-0.21575	
10002	0.27507	-0.48276	-0.05589	
10006	0.45859	0.51178	0.88394	
10008	-0.68742	0.04835	1.35192	
10010	-0.73207	-0.31512	-0.08387	

```
       nrmlight.B.nrm.sta.3  nrmlight.B.elev.exp.1  nrmlight.B.elev.exp.2  \
1000                -0.32312               -0.29853               -0.24846
10002               -0.37492                0.44073                0.60202
10006                0.54188                0.66271                1.68050
10008                0.53908               -0.12631               -0.86967
10010               -0.14934               -0.52712               -0.73413

       nrmlight.B.elev.exp.3  nrmlight.B.elev.sta.1  nrmlight.B.elev.sta.2  \
1000                 0.20443               -0.96469               -0.73780
10002                0.42461               -0.77719               -0.16530
10006                0.48628                0.86174                0.62019
10008                1.06930                0.28077                0.18448
10010               -0.06333               -0.24718               -0.07036

       nrmlight.B.elev.sta.3
1000                -0.29041
10002                0.20979
10006                1.07254
10008                0.91407
10010               -0.39420

[5 rows x 67 columns]
```

In [3]:
```
import re

def grepl(pattern, strings, values=False):
    out = np.array([bool(re.search(pattern, i)) for i in strings])
    if values:
        out = strings[out]
    return out

#def grepl(pattern, strings):
#    pd.Series(strings).str.contains(pattern).tolist()
```

In [4]:
```
colnames = r1.columns.values
print(colnames)
print(grepl('Dk', colnames))
colnames[grepl('Dk', colnames)]
```

```
['nrm_diel_Day1.Dk' 'nrm_diel_Day1.Lt' 'nrm_diel_Day2.Dk'
 'nrm_diel_Day2.Lt' 'nrm_diel_Day3.Dk' 'nrm_diel_Day3.Lt'
 'nrm_diel_Day4.Dk' 'nrm_diel_Day4.Lt' 'nrm_diel_Day5.Dk'
 'nrm_diel_Day5.Lt' 'elev_diel_Day1.Dk' 'elev_diel_Day1.Lt'
 'elev_diel_Day2.Dk' 'elev_diel_Day2.Lt' 'elev_diel_Day3.Dk'
 'elev_diel_Day3.Lt' 'elev_diel_Day4.Dk' 'elev_diel_Day4.Lt'
 'elev_diel_Day5.Dk' 'highlight.A.nrm.exp.1' 'highlight.A.nrm.exp.2'
 'highlight.A.nrm.exp.3' 'highlight.A.nrm.sta.1' 'highlight.A.nrm.sta.2'
 'highlight.A.nrm.sta.3' 'highlight.A.elev.exp.1' 'highlight.A.elev.exp.2'
 'highlight.A.elev.exp.3' 'highlight.A.elev.sta.1' 'highlight.A.elev.sta.2'
 'highlight.A.elev.sta.3' 'highlight.B.nrm.exp.1' 'highlight.B.nrm.exp.2'
 'highlight.B.nrm.exp.3' 'highlight.B.nrm.sta.1' 'highlight.B.nrm.sta.2'
 'highlight.B.nrm.sta.3' 'highlight.B.elev.exp.1' 'highlight.B.elev.exp.2'
 'highlight.B.elev.exp.3' 'highlight.B.elev.sta.1' 'highlight.B.elev.sta.2'
 'highlight.B.elev.sta.3' 'nrmlight.A.nrm.exp.1' 'nrmlight.A.nrm.exp.2'
 'nrmlight.A.nrm.exp.3' 'nrmlight.A.nrm.sta.1' 'nrmlight.A.nrm.sta.2'
 'nrmlight.A.nrm.sta.3' 'nrmlight.A.elev.exp.1' 'nrmlight.A.elev.exp.2'
 'nrmlight.A.elev.exp.3' 'nrmlight.A.elev.sta.1' 'nrmlight.A.elev.sta.2'
 'nrmlight.A.elev.sta.3' 'nrmlight.B.nrm.exp.1' 'nrmlight.B.nrm.exp.2'
 'nrmlight.B.nrm.exp.3' 'nrmlight.B.nrm.sta.1' 'nrmlight.B.nrm.sta.2'
 'nrmlight.B.nrm.sta.3' 'nrmlight.B.elev.exp.1' 'nrmlight.B.elev.exp.2'
```

```
 'nrmlight.B.elev.exp.3' 'nrmlight.B.elev.sta.1' 'nrmlight.B.elev.sta.2'
 'nrmlight.B.elev.sta.3']
[ True False  True False  True False  True False  True False  True False
  True False  True False  True False  True False False False False False
 False False False False False False False False False False False False
 False False False False False False False False False False False False
 False False False False False False False False False False False False
 False False False False False False False]
```

Out[4]:
```
array(['nrm_diel_Day1.Dk', 'nrm_diel_Day2.Dk', 'nrm_diel_Day3.Dk',
       'nrm_diel_Day4.Dk', 'nrm_diel_Day5.Dk', 'elev_diel_Day1.Dk',
       'elev_diel_Day2.Dk', 'elev_diel_Day3.Dk', 'elev_diel_Day4.Dk',
       'elev_diel_Day5.Dk'], dtype=object)
```

From Justin (it's in R):

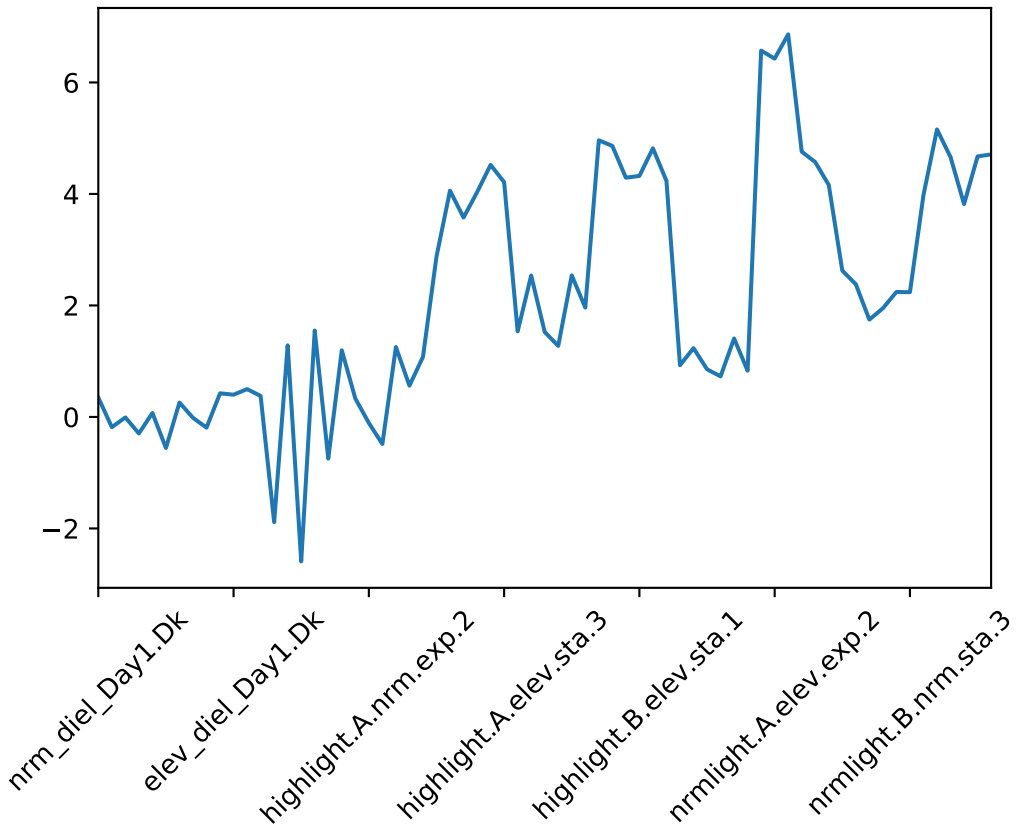
```
condclasses = list(
ã dark12hr = function(x){ grepl('Dk',x) },
ã light12hr = function(x){ grepl('Lt',x) },
ã exponential_diel = function(x){ grepl('diel_Day[12]',x) | grepl('diel_Day3.Dk',x) },
ã stationary_diel = function(x){ grepl('diel_Day[45]',x) | grepl('diel_Day3.Lt',x) },
ã exponential_24light = function(x){ grepl('nrmlight.+exp',x) },
ã stationary_24light = function(x){ grepl('nrmlight.+sta',x) },
ã exponential_24highlight = function(x){ grepl('highlight.+exp',x) },
ã stationary_24highlight = function(x){ grepl('highlight.+sta',x) },
ã highlight_arrays = function(x){ grepl('highlight',x) },
ã normallight_arrays = function(x){ grepl('nrmlight',x) },
ã co2_elevated_arrays = function(x){ grepl('elev',x) & !grepl('diel',x) },
ã co2_elevated_expo_arrays = function(x){ grepl('elev',x) & grepl('\\.exp',x) & !grepl('diel',x) },
ã co2_elevated_stat_arrays = function(x){ grepl('elev',x) & grepl('\\.sta',x) & !grepl('diel',x) },
ã co2_moderate_arrays = function(x){ grepl('nrm',x) & !grepl('elev',x) & !grepl('diel',x) },
ã co2_moderate_expo_arrays = function(x){ grepl('nrm',x) & grepl('\\.exp',x) & !grepl('elev',x) & !grepl('diel',x)
ã co2_moderate_stat_arrays = function(x){ grepl('nrm',x) & grepl('\\.sta',x) & !grepl('elev',x) & !grepl('diel',x)
)
```

In [5]:
```
# Convert to python:

condclasses = {
  'dark12hr': lambda x: grepl('Dk',x),
  'light12hr': lambda x: grepl('Lt',x),
  'exponential_diel': lambda x: grepl('diel_Day[12]',x) | grepl('diel_Day3.Dk',x),
  'stationary_diel': lambda x: grepl('diel_Day[45]',x) | grepl('diel_Day3.Lt',x),
  'exponential_24light': lambda x: grepl('nrmlight.+exp',x),
  'stationary_24light': lambda x: grepl('nrmlight.+sta',x),
  'exponential_24highlight': lambda x: grepl('highlight.+exp',x),
  'stationary_24highlight': lambda x: grepl('highlight.+sta',x),
  'highlight_arrays': lambda x: grepl('highlight',x),
  'normallight_arrays': lambda x: grepl('nrmlight',x),
  'co2_elevated_arrays': lambda x: grepl('elev',x), # & ~grepl('diel',x),
  'co2_elevated_expo_arrays': lambda x: grepl('elev',x) & grepl('\.exp',x), # & ~grepl('diel',x),
  'co2_elevated_stat_arrays': lambda x: grepl('elev',x) & grepl('\.sta',x), # & ~grepl('diel',x),
  'co2_moderate_arrays': lambda x: grepl('nrm',x) & ~grepl('elev',x), # & ~grepl('diel',x),
  'co2_moderate_expo_arrays': lambda x: grepl('nrm',x) & grepl('\.exp',x), # & ~grepl('elev',x) & ~grepl('
  'co2_moderate_stat_arrays': lambda x: grepl('nrm',x) & grepl('\.sta',x), # & ~grepl('elev',x) & ~grepl('
}
```

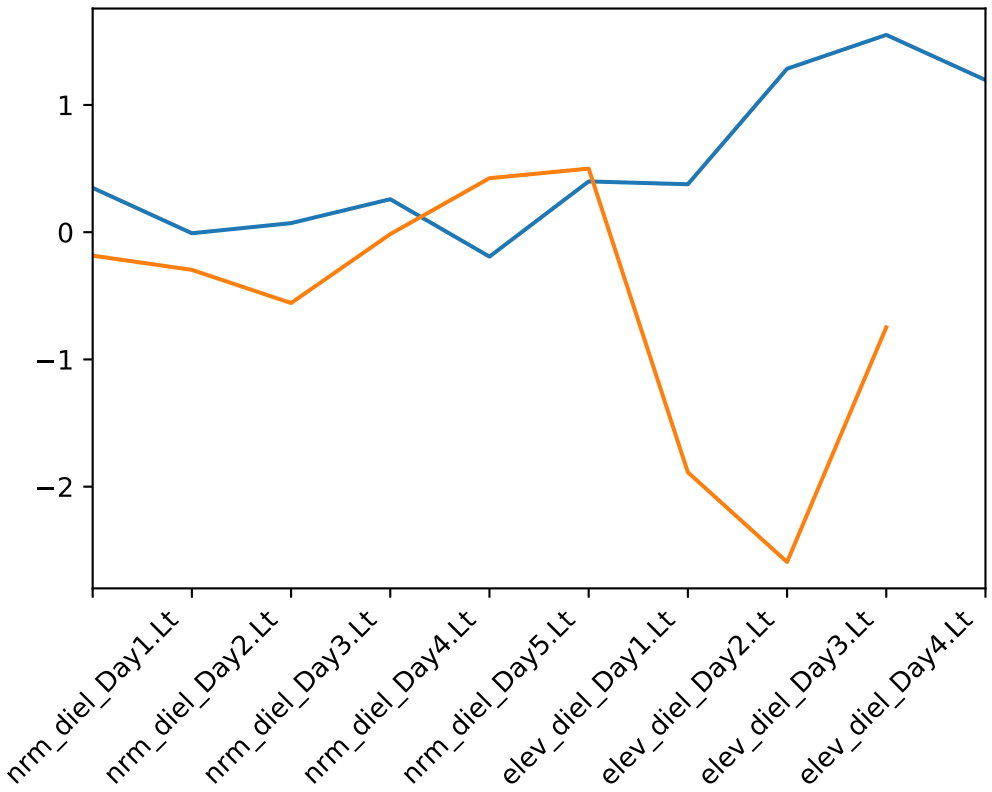
In [6]:
```
colnames[condclasses['dark12hr'](colnames)]
```

Out[6]:
```
array(['nrm_diel_Day1.Dk', 'nrm_diel_Day2.Dk', 'nrm_diel_Day3.Dk',
       'nrm_diel_Day4.Dk', 'nrm_diel_Day5.Dk', 'elev_diel_Day1.Dk',
       'elev_diel_Day2.Dk', 'elev_diel_Day3.Dk', 'elev_diel_Day4.Dk',
       'elev_diel_Day5.Dk'], dtype=object)
```

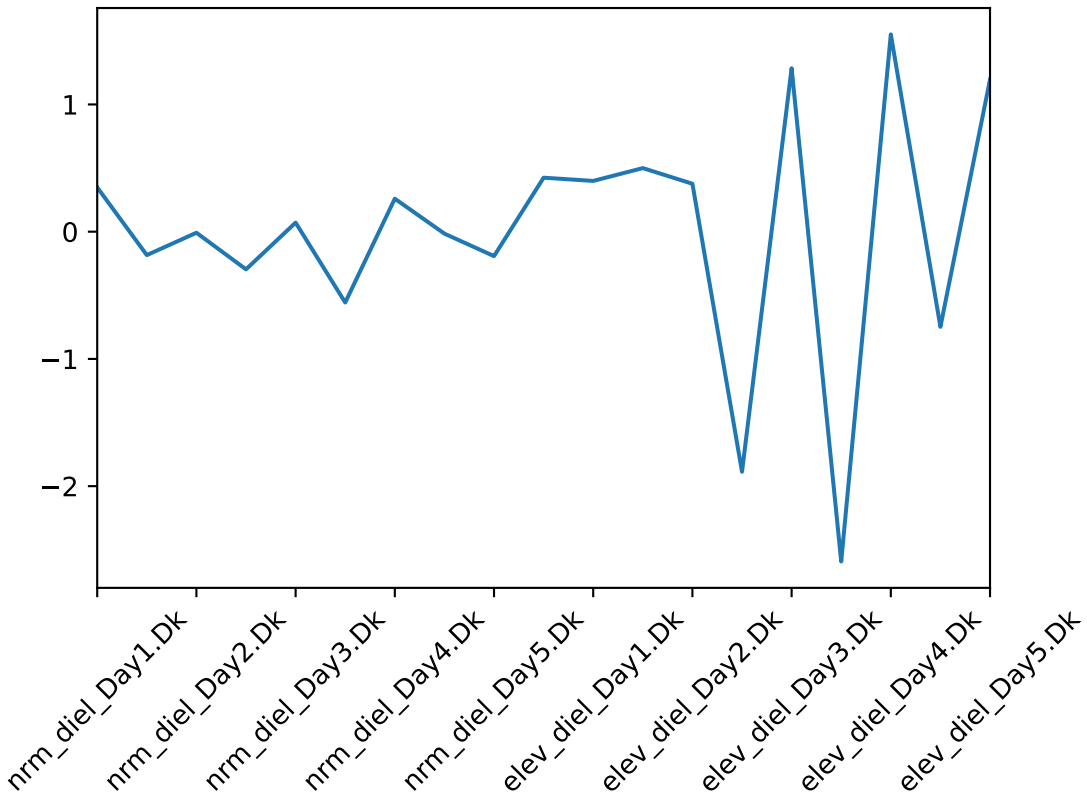
In [7]:
```
the_gene = 262258
ax = r1.loc[the_gene].plot()
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```



In [8]:
```
isdark = condclasses['dark12hr'](colnames)
islight = condclasses['light12hr'](colnames)
ax = r1.loc[the_gene, colnames[isdark]].plot()
ax = r1.loc[the_gene, colnames[islight]].plot()
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```



In [9]:
```
ax = r1.loc[the_gene, colnames[isdark | islight]].plot()
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```

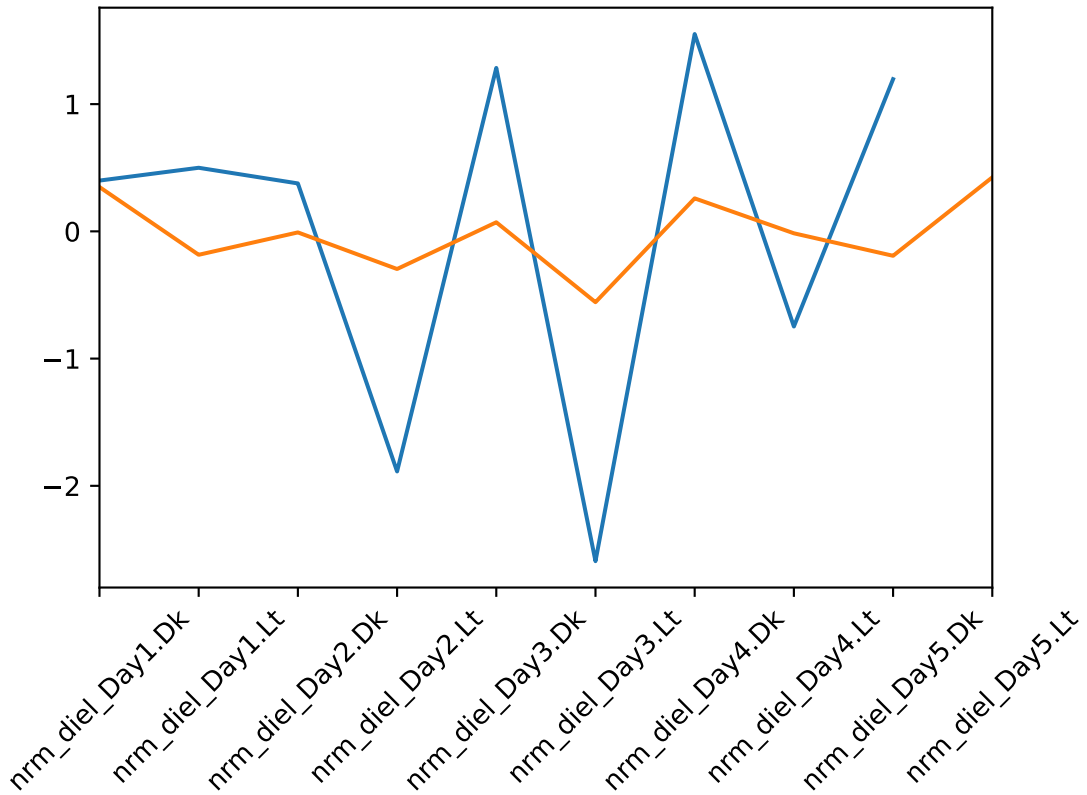


```
In [10]: #print(colnames[dark])
         #print(colnames[light])
         isco2_high = condclasses['co2_elevated_arrays'](colnames)
         isco2_low = condclasses['co2_moderate_arrays'](colnames)
         #print(colnames[co2_high])
```

```
In [11]: print(colnames[(isdark | islight) & isco2_high])
         print(colnames[(isdark | islight) & isco2_low])
```

```
['elev_diel_Day1.Dk' 'elev_diel_Day1.Lt' 'elev_diel_Day2.Dk'
 'elev_diel_Day2.Lt' 'elev_diel_Day3.Dk' 'elev_diel_Day3.Lt'
 'elev_diel_Day4.Dk' 'elev_diel_Day4.Lt' 'elev_diel_Day5.Dk']
['nrm_diel_Day1.Dk' 'nrm_diel_Day1.Lt' 'nrm_diel_Day2.Dk'
 'nrm_diel_Day2.Lt' 'nrm_diel_Day3.Dk' 'nrm_diel_Day3.Lt'
 'nrm_diel_Day4.Dk' 'nrm_diel_Day4.Lt' 'nrm_diel_Day5.Dk'
 'nrm_diel_Day5.Lt']
```

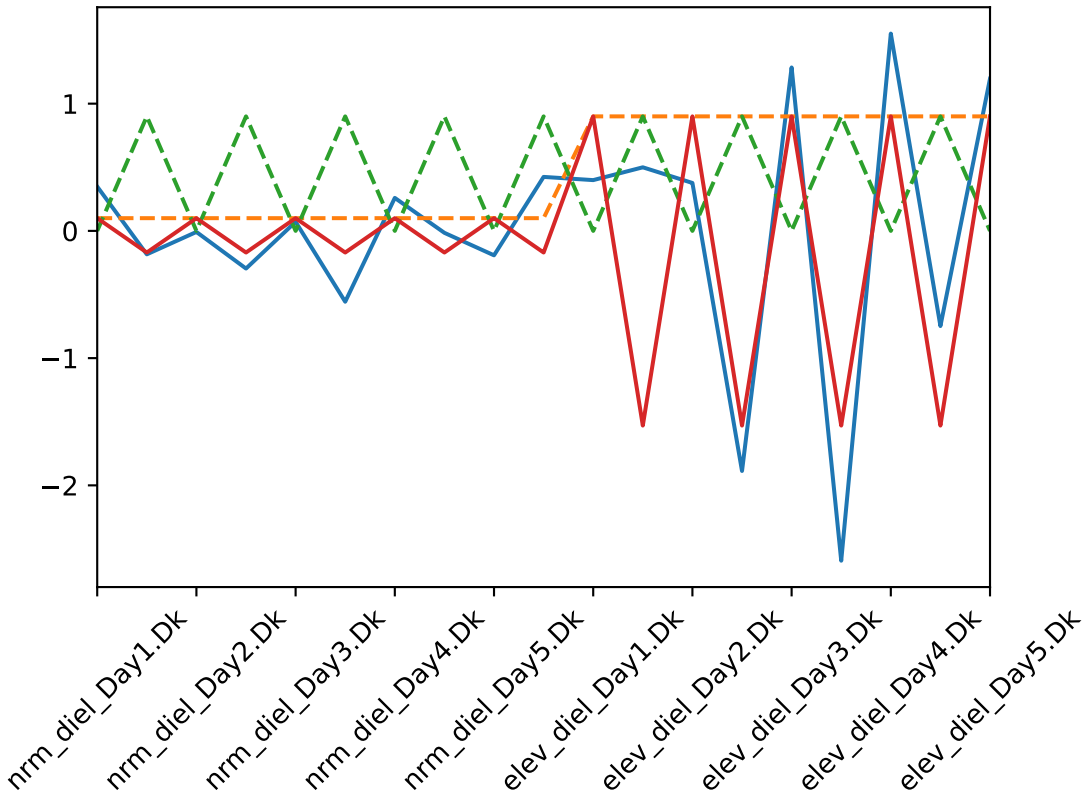
```
In [12]: ax = r1.loc[the_gene, colnames[(isdark | islight) & isco2_high]].plot()
         ax = r1.loc[the_gene, colnames[(isdark | islight) & isco2_low]].plot()
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```



Note here I call it 'isdark' but it's actually tracing the light since it is set to 0.1 for dark and 0.9 for light:

```
In [13]: co2 = np.where(isco2_high, 0.9, 0.1)
         dark = np.where(isdark, 0.0, 0.9)
         ax = r1.loc[the_gene, colnames[(isdark | islight)]].plot()
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
         ax.plot(co2[isdark | islight], ls='dashed')
         ax.plot(dark[isdark | islight], ls='dashed')
         ax.plot(-3. * (co2*dark)[isdark | islight] + 1. * co2[isdark | islight])
```

Out[13]: [<matplotlib.lines.Line2D at 0x11954e2e8>]



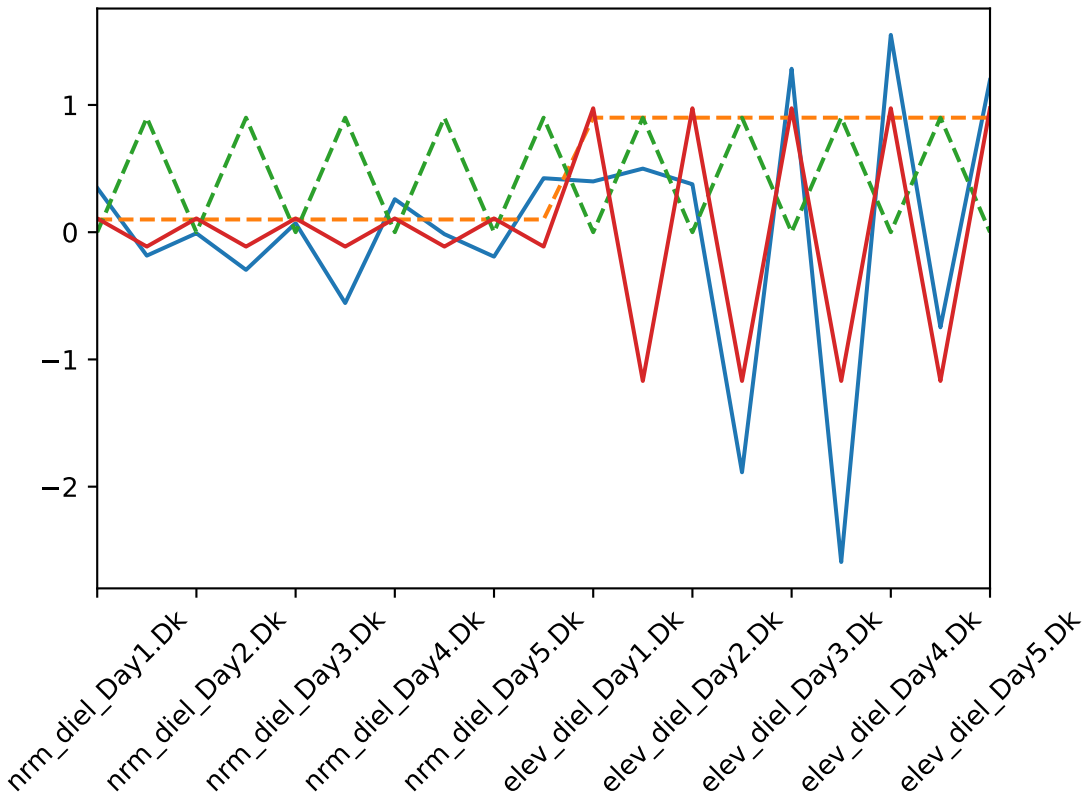
In [14]:
```
from sklearn import linear_model

y = r1.loc[the_gene, colnames[(isdark | islight)]]
x = np.vstack((np.ones_like(y),
               co2[isdark | islight],
               dark[isdark | islight],
               (co2*dark)[isdark | islight]))
print(x.shape, y.shape)
reg = linear_model.LinearRegression()
reg.fit(x.T, y) #, sample_weight=np.abs(y))
print(reg.score(x.T, y))  # R^2
reg.coef_
```

```
(4, 19) (19,)
0.583197557061
```

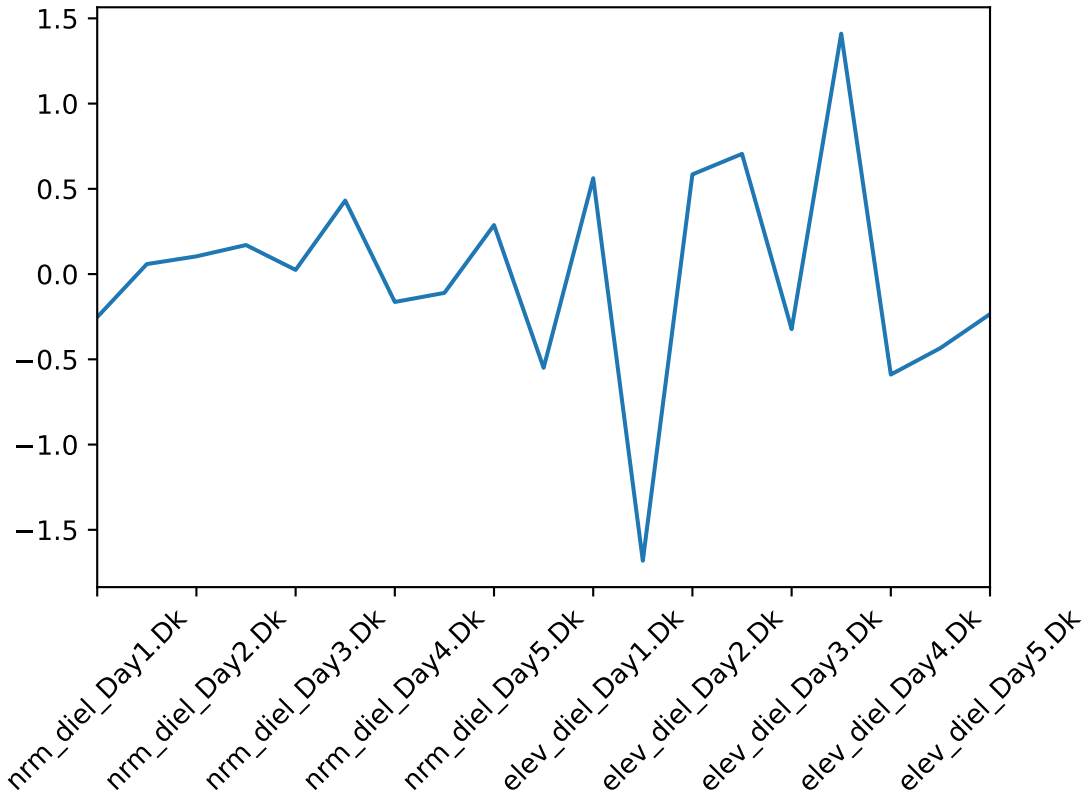
Out[14]: array([0.   , 1.08214   , 0.02106882, -2.66937708])

In [15]:
```
ax = r1.loc[the_gene, colnames[(isdark | islight)]].plot()
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
ax.plot(co2[isdark | islight], ls='dashed')
ax.plot(dark[isdark | islight], ls='dashed')
ax.plot(reg.coef_[3] * (co2*dark)[isdark | islight] +
        reg.coef_[1] * co2[isdark | islight] +
        reg.coef_[2] * dark[isdark | islight])
```

Out[15]: [<matplotlib.lines.Line2D at 0x11c4c5710>]



In [16]:
```
resids = reg.predict(x.T) - y
ax = resids.plot()
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```



Lets use statsmodels to get errors on coefficients.

In [17]:
```
import statsmodels.api as sm
results = sm.OLS(y, x.T).fit()
results.summary()
```

```
/Users/dreiss/miniconda3/lib/python3.6/site-packages/statsmodels/compat/pandas.py:56: FutureWarning: The pandas.co
  from pandas.core import datetools
/Users/dreiss/miniconda3/lib/python3.6/site-packages/scipy/stats/stats.py:1334: UserWarning: kurtosistest only vali
  "anyway, n=%i" % int(n))
```

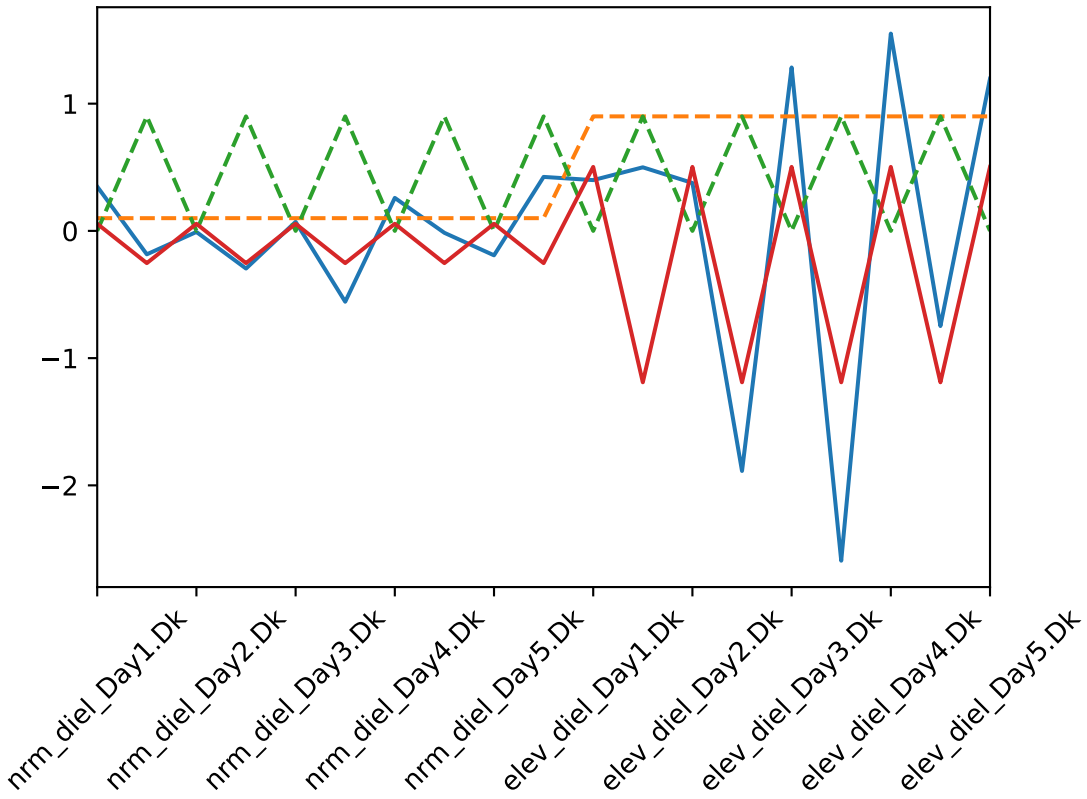
Out[17]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            OLS Regression Results
==============================================================================
Dep. Variable:                 262258   R-squared:                       0.583
Model:                            OLS   Adj. R-squared:                  0.500
Method:                 Least Squares   F-statistic:                     6.996
Date:                Fri, 23 Jun 2017   Prob (F-statistic):            0.00363
Time:                        15:50:17   Log-Likelihood:                -17.982
No. Observations:                  19   AIC:                             43.96
Df Residuals:                      15   BIC:                             47.74
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0125      0.355     -0.035      0.972      -0.770       0.745
x1             1.0821      0.555      1.951      0.070      -0.100       2.264
x2             0.0211      0.559      0.038      0.970      -1.169       1.212
x3            -2.6694      0.898     -2.971      0.010      -4.584      -0.754
==============================================================================
Omnibus:                        4.009   Durbin-Watson:                   2.851
Prob(Omnibus):                  0.135   Jarque-Bera (JB):                2.024
Skew:                           0.354   Prob(JB):                        0.363
Kurtosis:                       4.433   Cond. No.                         8.56
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
"""
```

Try Lasso...

In [18]:
```
reg = linear_model.LassoLars(alpha=0.02)
reg.fit(x.T, y) #, sample_weight=np.abs(y))
print(reg.score(x.T, y))  # R^2
print(reg.coef_)

ax = r1.loc[the_gene, colnames[(isdark | islight)]].plot()
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
ax.plot(co2[isdark | islight], ls='dashed')
ax.plot(dark[isdark | islight], ls='dashed')
ax.plot(reg.coef_[3] * (co2*dark)[isdark | islight] +
        reg.coef_[1] * co2[isdark | islight] +
        reg.coef_[2] * dark[isdark | islight])
```

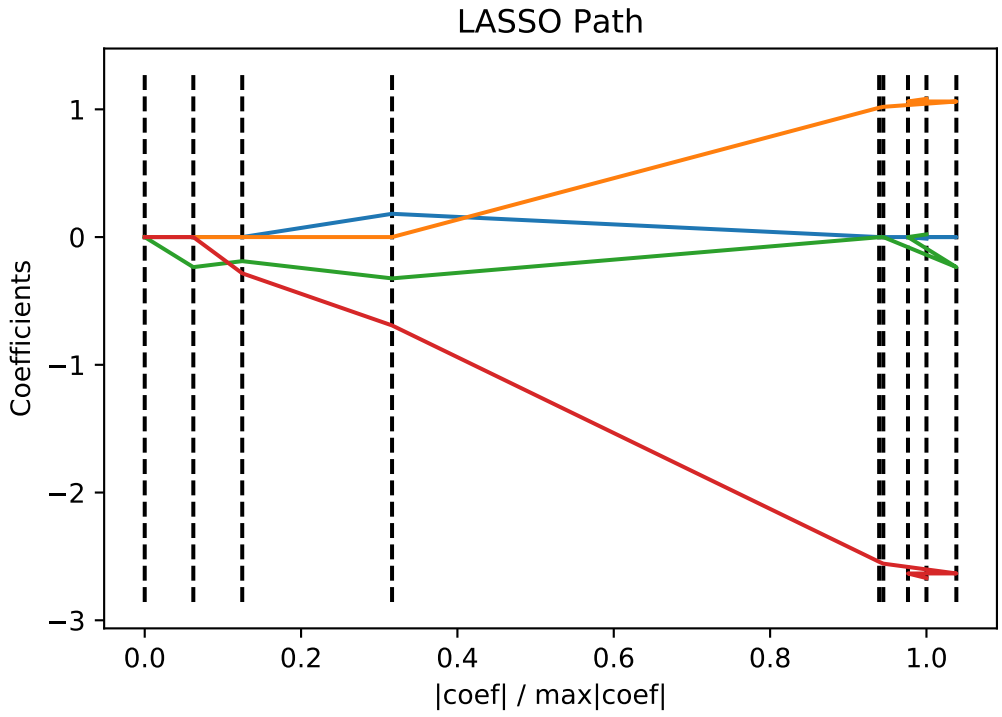
```
0.548514155569
[ 0.          0.55873282 -0.15137112 -1.92173963]
```

Out[18]: [<matplotlib.lines.Line2D at 0x11d4c2470>]



In [19]:
```
alphas, _, coefs = linear_model.lars_path(x.T, y, method='lasso', verbose=True)

xx = np.sum(np.abs(coefs.T), axis=1)
xx /= xx[-1]

plt.plot(xx, coefs.T)
ymin, ymax = plt.ylim()
plt.vlines(xx, ymin, ymax, linestyle='dashed')
plt.xlabel('|coef| / max|coef|')
plt.ylabel('Coefficients')
plt.title('LASSO Path')
plt.axis('tight')
plt.show()
```

.



Try k-means to get a cluster containing this super awesome gene...

```
In [20]: from sklearn.preprocessing import scale
         print(r1.shape)
         print(np.mean(np.isnan(r1.values)))
         r1norm = r1.dropna(axis=0, how='all', thresh=None, subset=None, inplace=False)
         print(r1norm.shape)
         r1norm = r1norm.loc[:, colnames[(isdark | islight)]]
         #print(np.mean(np.isnan(r1norm)))
         r1norm.fillna(0., inplace=True)
         r1norm.values[:, :] = scale(r1norm.values)
         print(r1norm.shape)
```

```
(12099, 67)
0.0190554788665
(12099, 67)
(12099, 19)
```

```
In [21]: from sklearn.cluster import KMeans
         np.random.seed(4)
         km = KMeans(n_clusters=1200, init='k-means++', n_init=10, max_iter=20,
                     tol=0.0001, precompute_distances='auto', verbose=0, random_state=None,
                     copy_x=True, n_jobs=1, algorithm='auto')
         km.fit(r1norm)
         labels = km.labels_
         print(len(labels))
         labels
```

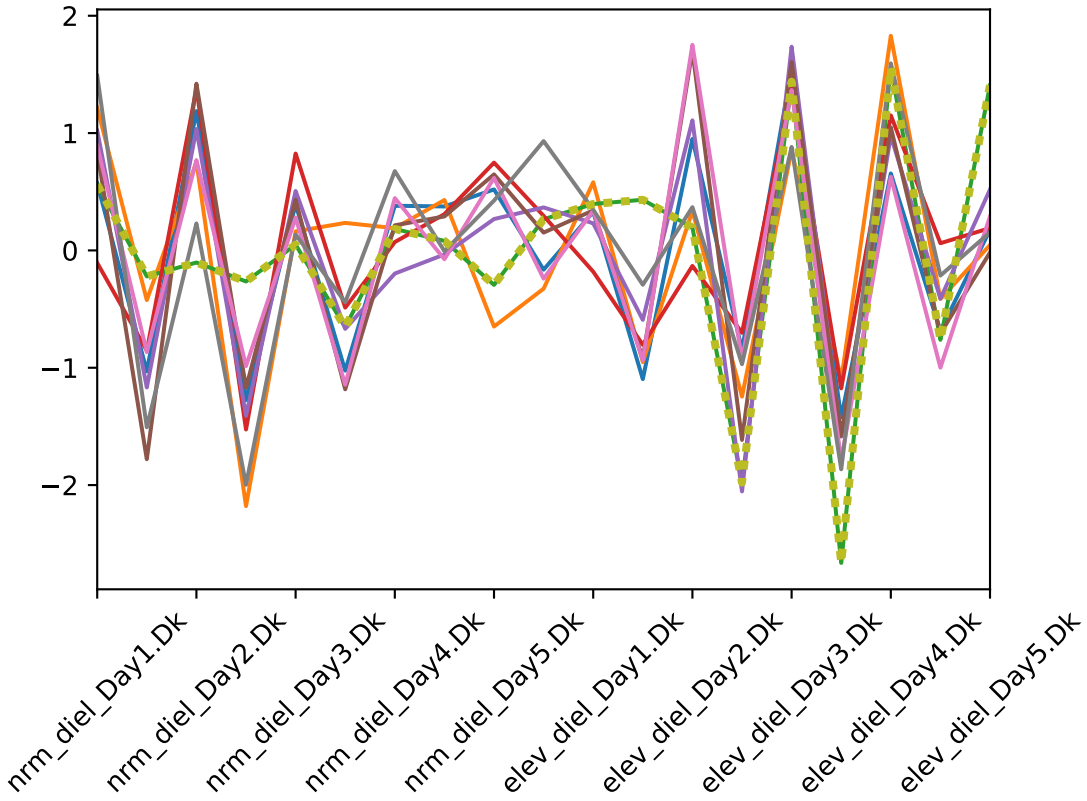
```
12099
```

```
Out[21]: array([713, 618, 878, ..., 226, 226, 654], dtype=int32)
```

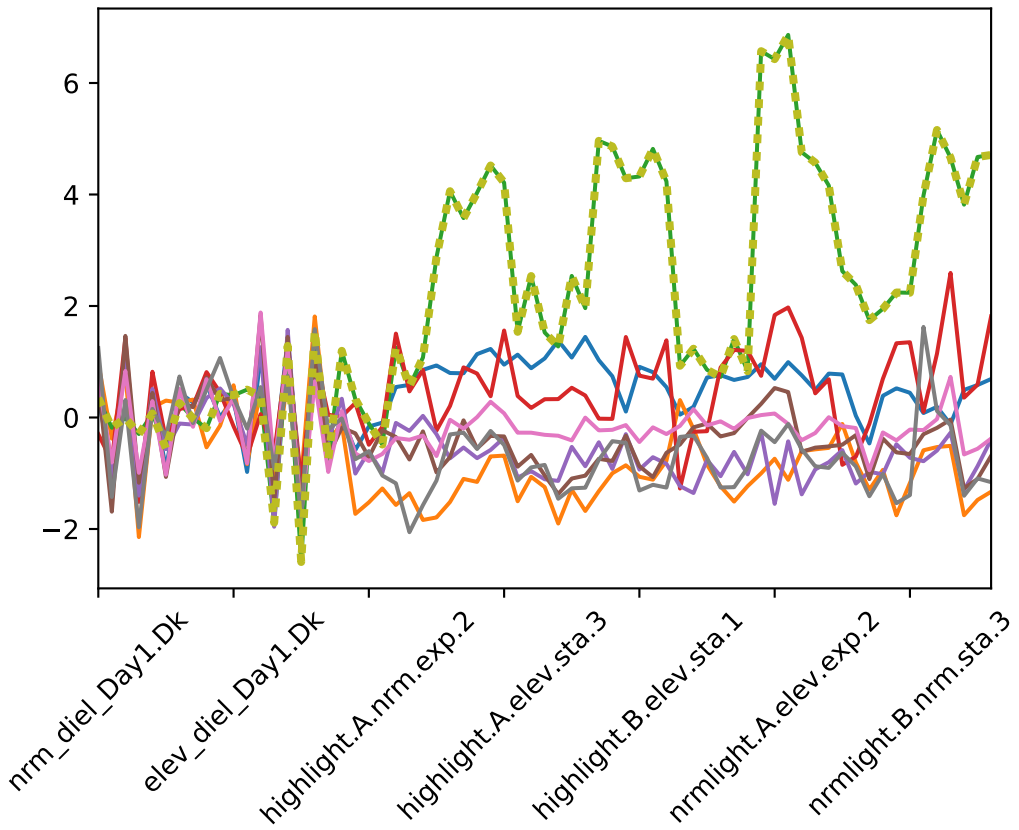
```
In [22]: index = labels[np.where(r1.index.values == the_gene)]
         print(index)
```

```
        genes = r1.index.values[np.where(labels == index)]
        print(len(genes))
        print(the_gene in genes)
        print(genes)

        ax = r1norm.loc[genes].T.plot(legend=False)
        plt.plot(r1norm.loc[the_gene, :].values, ls='dotted', lw=3)
        ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```

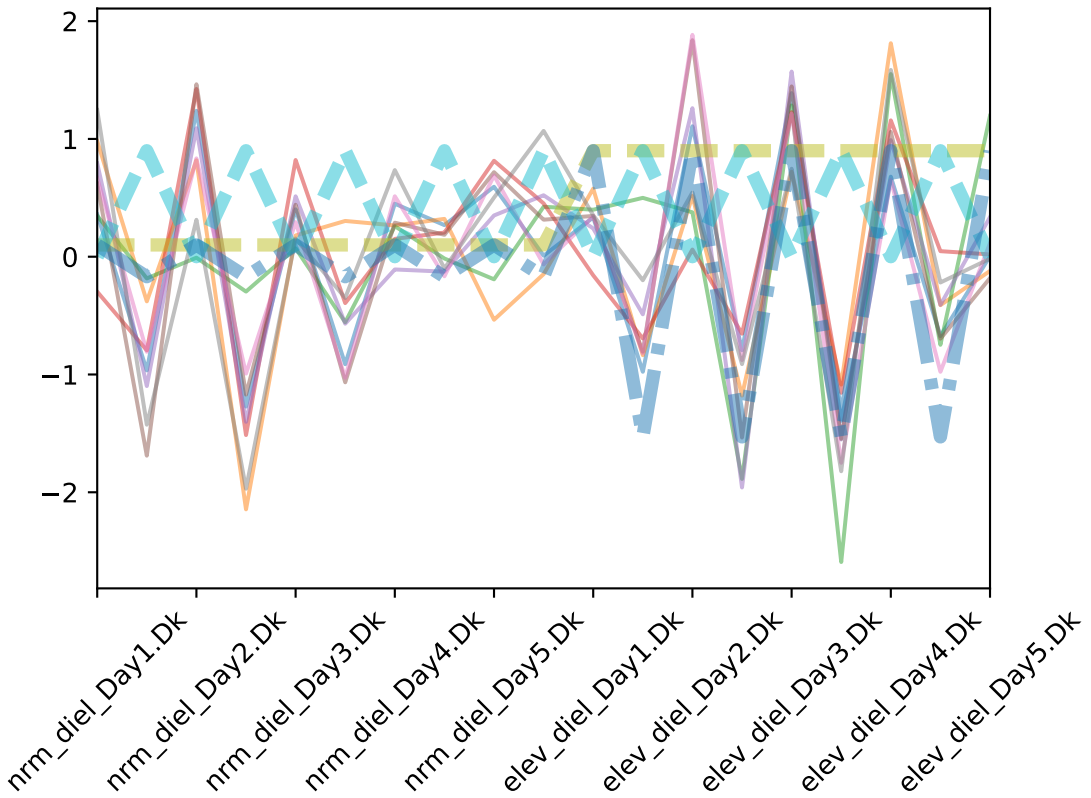
```
[601]
8
True
[14096 25744 262258 264821 34170 '6010' '9135' '9976']
```



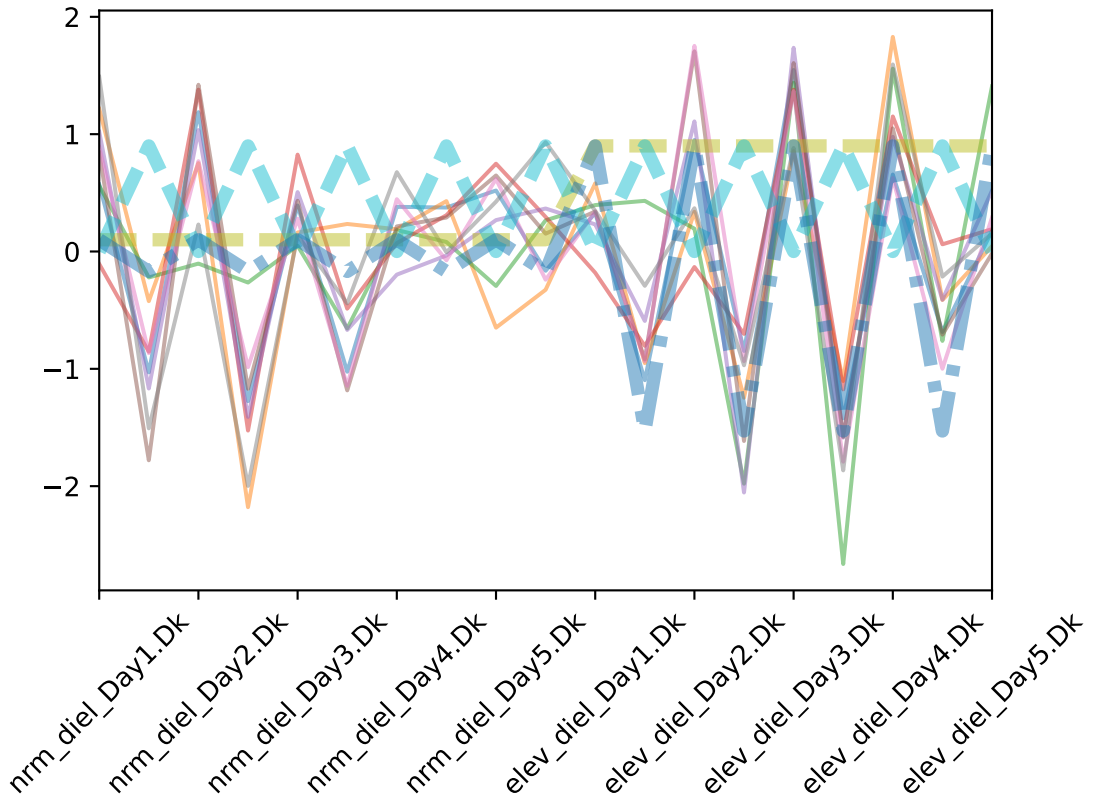
In [23]:
```
ax = r1.loc[genes].T.plot(legend=False)
plt.plot(r1.loc[the_gene, :].values, ls='dotted', lw=3)
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
```



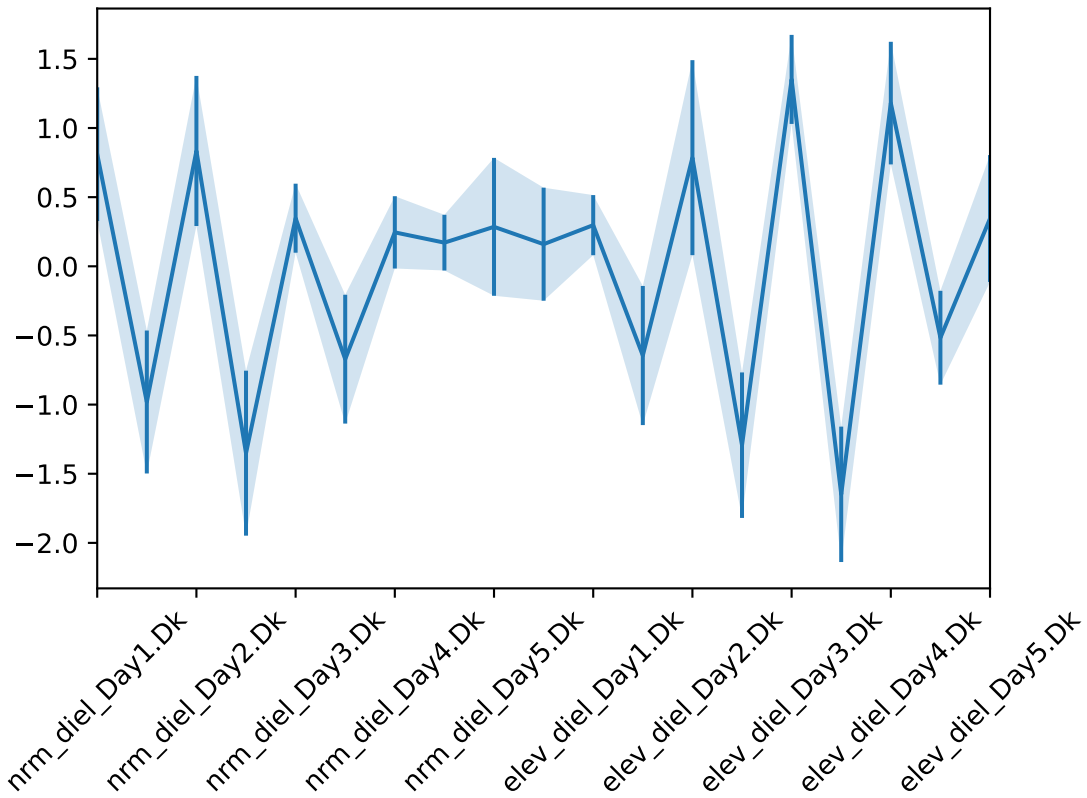

```
In [24]: ax = r1.loc[genes, colnames[(isdark | islight)]].T.plot(legend=False, alpha=0.5)
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45)
         ax.plot(co2[isdark | islight], ls='dashed', lw=5, alpha=0.5)
         ax.plot(dark[isdark | islight], ls='dashed', lw=5, alpha=0.5)
         ax.plot(-3. * (co2*dark)[isdark | islight] + 1. * co2[isdark | islight], lw=5, alpha=0.5, ls='dashdot')

Out[24]: [<matplotlib.lines.Line2D at 0x119055438>]
```




```
In [25]: r1a = r1.copy()
         r1a.loc[:, colnames[(isdark | islight)]] = r1norm
         ax = r1a.loc[genes, colnames[(isdark | islight)]].T.plot(legend=False, alpha=0.5)
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45)
         ax.plot(co2[isdark | islight], ls='dashed', lw=5, alpha=0.5)
         ax.plot(dark[isdark | islight], ls='dashed', lw=5, alpha=0.5)
         ax.plot(-3. * (co2*dark)[isdark | islight] + 1. * co2[isdark | islight], lw=5, alpha=0.5, ls='dashdot')

Out[25]: [<matplotlib.lines.Line2D at 0x119946d30>]
```




```
In [26]: mn = r1a.loc[genes, colnames[(isdark | islight)]].mean()
         err = r1a.loc[genes, colnames[(isdark | islight)]].std()
         ax = mn.plot(yerr=err)
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
         ax.fill_between(range(len(mn)), mn-err, mn+err, alpha=0.2)

Out[26]: <matplotlib.collections.PolyCollection at 0x11c964ef0>
```



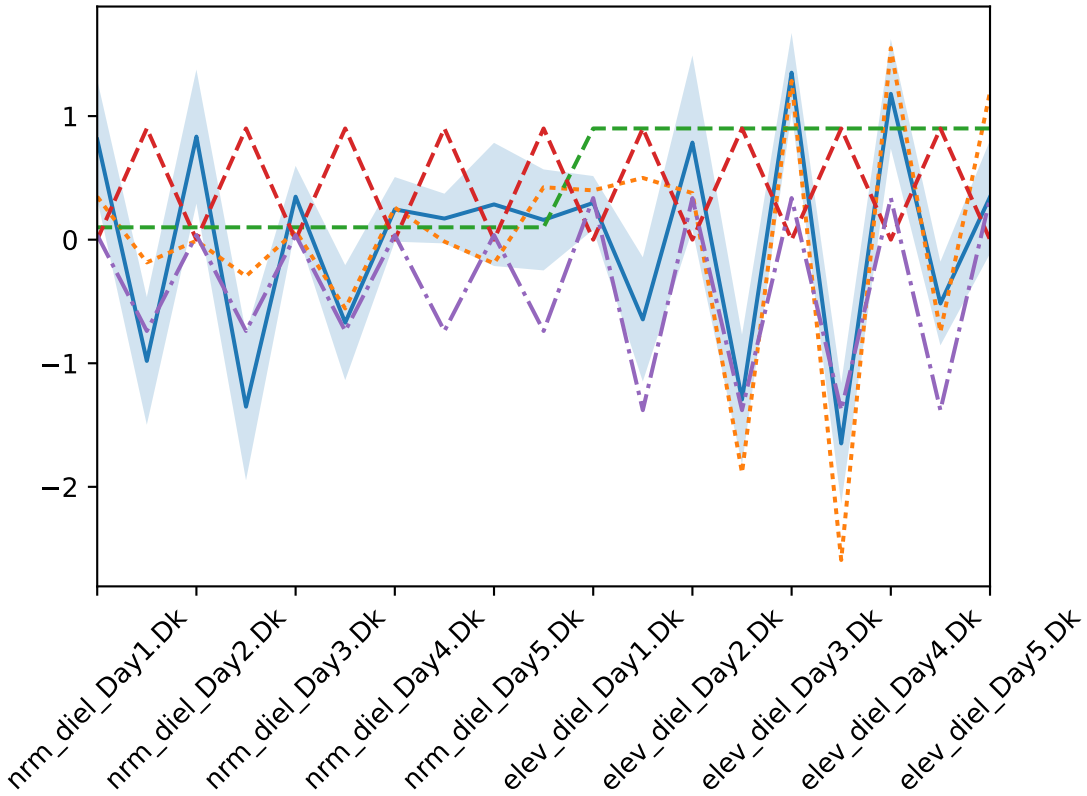

```
In [27]: reg = linear_model.LinearRegression()
         reg.fit(x.T, mn, sample_weight=1/err)
         print(reg.score(x.T, y, sample_weight=1/err))  # R^2
         reg.coef_
```

```
0.514930892128
```

```
Out[27]: array([ 0.        ,  0.37437859, -0.73216368, -1.30594988])
```

```
In [28]: ax = mn.plot() #yerr=err)
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
         ax.fill_between(range(len(mn)), mn-err, mn+err, alpha=0.2)
         ax.plot(r1.loc[the_gene, colnames[(isdark | islight)]].values, ls='dotted')
         ax.plot(co2[isdark | islight], ls='dashed')
         ax.plot(dark[isdark | islight], ls='dashed')
         ax.plot(reg.coef_[3] * (co2*dark)[isdark | islight] +
                 reg.coef_[1] * co2[isdark | islight] +
                 reg.coef_[2] * dark[isdark | islight], ls='dashdot')
```

```
Out[28]: [<matplotlib.lines.Line2D at 0x10cfe8a20>]
```



In [29]:
```
results = sm.WLS(mn, x.T, weights=1/err**2.).fit()
results.summary()
```

```
/Users/dreiss/miniconda3/lib/python3.6/site-packages/scipy/stats/stats.py:1334: UserWarning: kurtosistest only vali
  "anyway, n=%i" % int(n))
```

Out[29]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            WLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.603
Model:                            WLS   Adj. R-squared:                  0.523
Method:                 Least Squares   F-statistic:                     7.588
Date:                Fri, 23 Jun 2017   Prob (F-statistic):            0.00257
Time:                        15:51:32   Log-Likelihood:                -13.191
No. Observations:                  19   AIC:                             34.38
Df Residuals:                      15   BIC:                             38.16
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.3576      0.231      1.548      0.143      -0.135       0.850
x1             0.3465      0.360      0.962      0.351      -0.421       1.114
x2            -0.4321      0.366     -1.182      0.256      -1.211       0.347
x3            -1.4702      0.639     -2.300      0.036      -2.833      -0.108
==============================================================================
Omnibus:                        1.660   Durbin-Watson:                   2.906
Prob(Omnibus):                  0.436   Jarque-Bera (JB):                0.931
Skew:                          -0.010   Prob(JB):                        0.628
```

```
Kurtosis:                       1.915   Cond. No.                         8.22
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
"""
```

Find clusters that may be anticorrelated with `the_gene`.

```
In [30]: def get_cluster_profile(ind):
             genes = r1.index.values[np.where(labels == ind)]
             mn1 = r1a.loc[genes, colnames[(isdark | islight)]].mean()
             err1 = r1a.loc[genes, colnames[(isdark | islight)]].std()
             return mn1, err1

         for lab in range(max(labels)):
             mn1, _ = get_cluster_profile(lab)
             corr = np.corrcoef(mn1, mn)[0, 1]
             if np.abs(corr) > 0.85:
                 print(lab, corr)
```

```
16 0.875917093914
17 -0.886837101736
26 0.913622075356
51 0.947320514238
58 0.900811857266
103 -0.878456522929
112 0.934666079963
170 -0.893175978822
174 0.879700896006
180 0.932091999425
235 0.902334600112
264 0.881464889712
309 0.913380606222
381 0.870723547997
384 0.85208112038
439 0.931438462027
443 0.934761774506
464 0.854619922791
495 -0.852214388152
528 -0.885249195782
535 0.918347994424
552 0.869160951163
601 1.0
646 0.876867077841
650 0.883170107871
719 0.904411250974
731 0.880618583152
749 0.92443441189
751 0.878472346778
803 0.900515585077
917 -0.868159627678
935 0.928134219879
956 0.851196891911
1042 -0.860309777686
1067 0.923141483006
1126 0.910982499787
1146 0.860771335809
1149 -0.884697663519
1198 0.8879071125
```

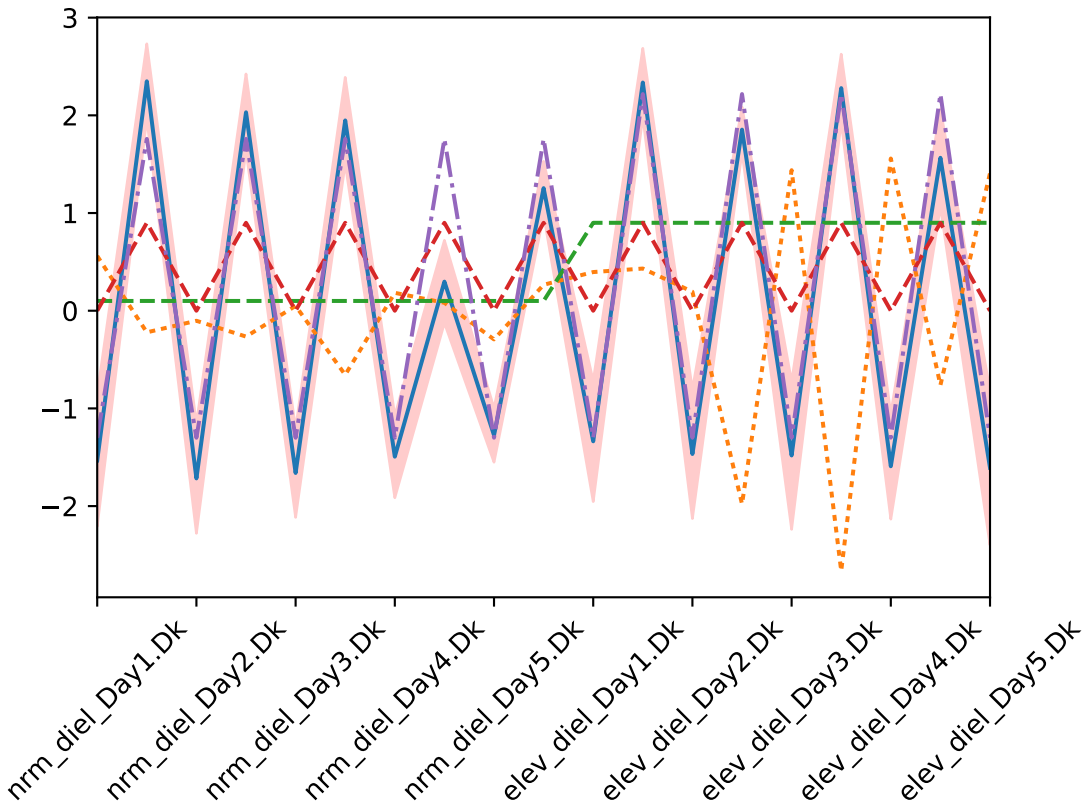
In [39]:
```
mn1, err1 = get_cluster_profile(528)
reg.fit(x.T, mn1, sample_weight=1/err1)
print(reg.score(x.T, mn1, sample_weight=1/err1))  # R^2
reg.coef_
```

```
0.936274009299
```

Out[39]:
```
array([  0.00000000e+00,   7.36263613e-04,   3.33502289e+00,
         6.36520342e-01])
```

In [45]:
```
ax = mn1.plot() #yerr=err)
ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
ax.fill_between(range(len(mn1)), mn1-err1, mn1+err1, alpha=0.2, color='r')
ax.plot(r1a.loc[the_gene, colnames[(isdark | islight)]].values, ls='dotted')
ax.plot(co2[isdark | islight], ls='dashed')
ax.plot(dark[isdark | islight], ls='dashed')
ax.plot(-1.3 +
        reg.coef_[3] * (co2*dark)[isdark | islight] +
        reg.coef_[1] * co2[isdark | islight] +
        reg.coef_[2] * dark[isdark | islight], ls='dashdot')

#mn1, err1 = get_cluster_profile(528)
#ax.plot(mn1.values, ls='dotted', lw=3, c='r')
#ax.fill_between(range(len(mn1)), mn1-err1, mn1+err1, alpha=0.2, color='r')
```

Out[45]:
```
[<matplotlib.lines.Line2D at 0x11db82f60>]
```



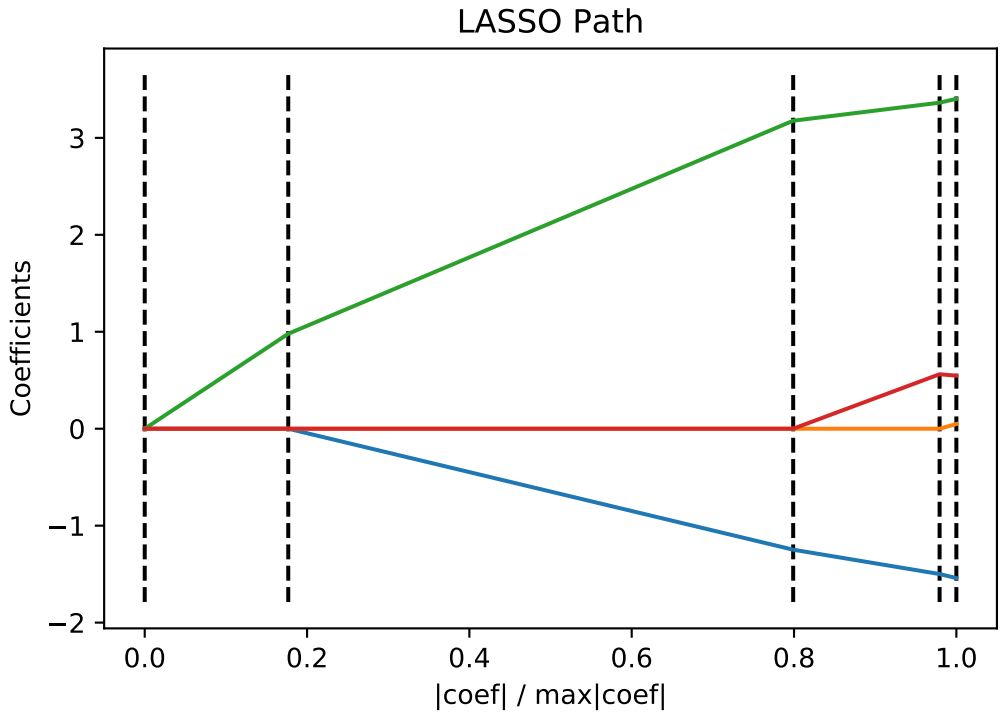
In [33]:
```
results = sm.WLS(mn1, x.T, weights=1/err1**2.).fit()
results.summary()
```

```
/Users/dreiss/miniconda3/lib/python3.6/site-packages/scipy/stats/stats.py:1334: UserWarning: kurtosistest only vali
  "anyway, n=%i" % int(n))
```

Out[33]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                            WLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.933
Model:                            WLS   Adj. R-squared:                  0.920
Method:                 Least Squares   F-statistic:                     70.00
Date:                Fri, 23 Jun 2017   Prob (F-statistic):           4.75e-09
Time:                        15:51:37   Log-Likelihood:                -12.514
No. Observations:                  19   AIC:                             33.03
Df Residuals:                      15   BIC:                             36.80
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.4441      0.247     -5.851      0.000      -1.970      -0.918
x1            -0.0572      0.504     -0.114      0.911      -1.131       1.017
x2             3.2510      0.364      8.931      0.000       2.475       4.027
x3             0.7214      0.671      1.076      0.299      -0.708       2.151
==============================================================================
Omnibus:                        5.871   Durbin-Watson:                   2.496
Prob(Omnibus):                  0.053   Jarque-Bera (JB):                3.527
Skew:                          -0.660   Prob(JB):                        0.171
Kurtosis:                       4.646   Cond. No.                         10.7
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
"""
```

In [34]:
```
alphas, _, coefs = linear_model.lars_path(x.T, mn1, method='lasso', verbose=True)

xx = np.sum(np.abs(coefs.T), axis=1)
xx /= xx[-1]

plt.plot(xx, coefs.T)
ymin, ymax = plt.ylim()
plt.vlines(xx, ymin, ymax, linestyle='dashed')
plt.xlabel('|coef| / max|coef|')
plt.ylabel('Coefficients')
plt.title('LASSO Path')
plt.axis('tight')
plt.show()
```

.



In [ ]:

Try fitting all clusters, see if we can find different combo's of coefficients. Especially look for ones which only are affected by co2 (param x1, or index 1).

In [35]:
```
reg = linear_model.LinearRegression()

def fit_cluster(ind):
    mn, std = get_cluster_profile(ind)
    reg.fit(x.T, mn) #, sample_weight=np.abs(y))
    score = reg.score(x.T, mn)  # R^2
    return reg.coef_, score

scores = [fit_cluster(ind) for ind in range(1200)]
```

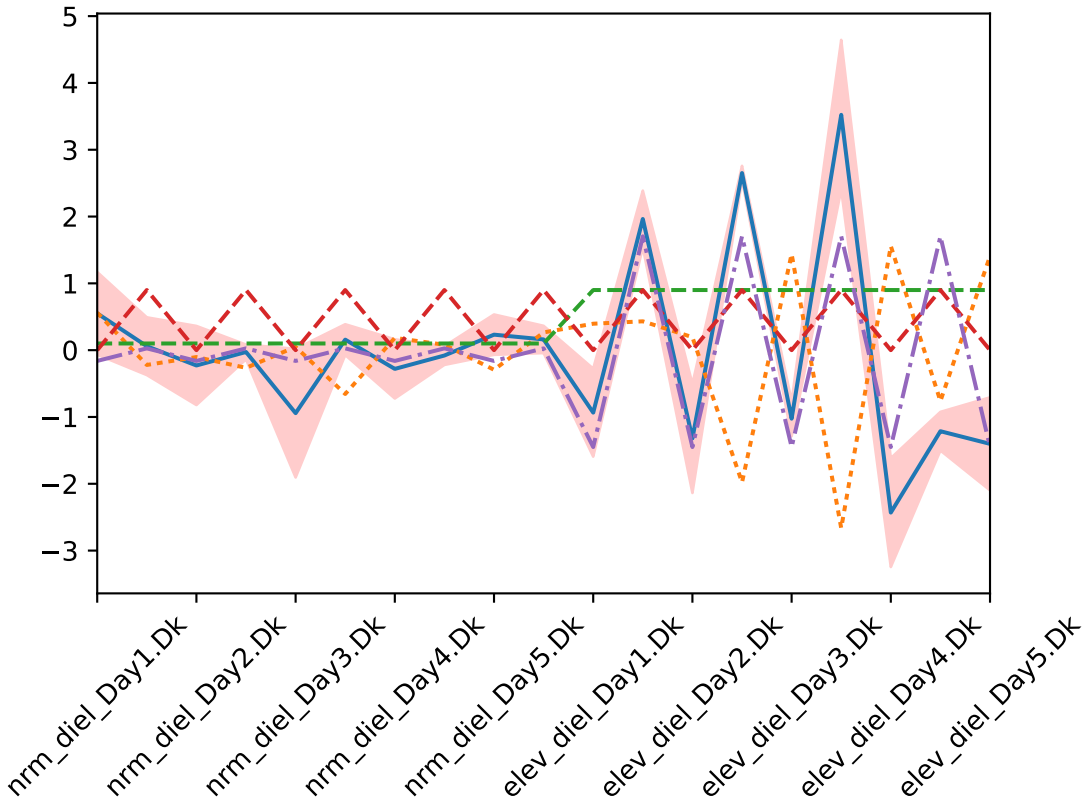
In [36]:
```
#co2_coeffs = np.array([sc[0][1] for sc in scores])
#print(np.min(co2_coeffs), np.max(co2_coeffs))
#lab = np.argmin(co2_coeffs)
#print(lab)
#print(scores[lab])

for i in range(1200):
    sc = scores[i]
    if np.abs(sc[0][1]) > np.abs(sc[0][2]) + np.abs(sc[0][3]): # and sc[1] > 0.4:
        print(i, sc)

# Not finding much!
```

```
7 (array([ 0.        ,  0.02805658, -0.01060968, -0.01539051]), 0.014527977498730138)
123 (array([ 0.        ,  0.13014645,  0.01530956, -0.06231341]), 0.0053610042689555826)
153 (array([ 0.        , -0.18053608, -0.12957559,  0.02376715]), 0.0024103419863978903)
209 (array([ 0.        ,  0.1339631 ,  0.01378686, -0.05484272]), 0.0027783321125754985)
273 (array([ 0.        ,  0.16378924,  0.10021357, -0.04324233]), 0.015875872136872027)
329 (array([ 0.        ,  0.10394438,  0.0102262 , -0.0160302 ]), 0.0064332734534413571)
```

```
351 (array([ 0.        ,  0.49059658, -0.04136066, -0.18041325]), 0.0033111682453613733)
422 (array([ 0.        , -0.28258216,  0.04348452,  0.10745876]), 0.0054957613118427062)
480 (array([ 0.        , -0.14819229, -0.07165215,  0.01274871]), 0.011380127029799403)
564 (array([ 0.        ,  0.26590792,  0.01590301, -0.13498175]), 0.0087819132474280526)
570 (array([ 0.        , -0.88246099, -0.4512164 ,  0.16506981]), 0.015400235591607081)
822 (array([ 0.        ,  0.10831328,  0.04421293,  0.00537372]), 0.0084467502221186042)
1069 (array([ 0.        , -0.40087296,  0.08233548,  0.26586085]), 0.010932752350386599)
```

Try to look for all cases of high interaction (co2 * light):

```
In [37]: print(scores[601])

         for i in range(1200):
             sc = scores[i]
             if np.abs(sc[0][3]) > 1. and np.abs(sc[0][3]) > 2.*np.abs(sc[0][2]) and sc[1] > 0.4:
                 print(i, sc)

(array([ 0.        ,  0.35925953, -1.04670126, -1.08165068]), 0.71631563247766072)
459 (array([ 0.        , -1.15503253,  0.47029975,  2.98318686]), 0.51592706479888784)
755 (array([ 0.        , -1.6113901 , -0.20309454,  4.11958912]), 0.58824159983905022)
1105 (array([ 0.        , -0.63498353,  0.49535103,  1.50899811]), 0.55388881195919604)


In [38]: mn1, err1 = get_cluster_profile(755)
         ax = mn1.plot()
         #ax.plot(mn1.values, ls='dotted', lw=3, c='r')
         ax.set_xticklabels(ax.xaxis.get_majorticklabels(), rotation=45);
         ax.fill_between(range(len(mn1)), mn1-err1, mn1+err1, alpha=0.2, color='r')

         ax.plot(r1a.loc[the_gene, colnames[(isdark | islight)]].values, ls='dotted')
         ax.plot(co2[isdark | islight], ls='dashed')
         ax.plot(dark[isdark | islight], ls='dashed')
         coef = scores[755][0]
         ax.plot(coef[3] * (co2*dark)[isdark | islight] +
                 coef[1] * co2[isdark | islight] +
                 coef[2] * dark[isdark | islight], ls='dashdot')

Out[38]: [<matplotlib.lines.Line2D at 0x118fb84e0>]
```


5
4
3
2
1
0
−1
−2
−3
nrm_diel_Day1.Dk
nrm_diel_Day2.Dk
nrm_diel_Day3.Dk
nrm_diel_Day4.Dk
nrm_diel_Day5.Dk
elev_diel_Day1.Dk
elev_diel_Day2.Dk
elev_diel_Day3.Dk
elev_diel_Day4.Dk
elev_diel_Day5.Dk

In [ ]: