README for FallowFox Project

This document outlines the general file structure and methodology of the FallowFox Project, which is all under the FallowFox folder in the Larsen Drive. The table of contents below shows this structure, with two main folders under FallowFox: R and ConnectivityTools. This document covers the R methods/data structure under the R folder, as well as the Connectivity Tools used (Circuitscape and Linkage Mapper). Connectivity processes were run on the computer’s C drive, and the final results moved to the server under the ConnectivityTools folder.

Table of Contents

[R/FallowFox 1](#_Toc59197329)

[Rmd 1](#_Toc59197330)

[1\_DataProcessing.Rmd 2](#_Toc59197331)

[2\_Analysis.Rmd 2](#_Toc59197332)

[Data 3](#_Toc59197333)

[1\_DataProcessing 3](#_Toc59197334)

[2\_Analysis 6](#_Toc59197335)

[R 6](#_Toc59197336)

[1\_DataProcessing 6](#_Toc59197337)

[ConnectivityTools 9](#_Toc59197338)

[Circuitscape for ArcGIS 2013 9](#_Toc59197339)

[Linkage Mapper 2\_0\_0 9](#_Toc59197340)

[Results 10](#_Toc59197341)

# R/FallowFox

## Rmd

These two Rmd go through the methodology of the whole project. DataProcessing creates the spatial files needed for the connectivity analyses in ArcGIS, and then analysis reads the ArcGIS connectivity products back in for statistical analyses. These Rmd files provide far more detailed information for how files are used, outputs, and decisions made.

### 1\_DataProcessing.Rmd

This R markdown document prepares the datasets needed to run the spatial connectivity analyses for examining how agricultural abandonment and fallowed fields can influence species connectivity in Kern County, focusing on the San Joaquin Kit Fox as a case study subject. The scripts create the Kit Fox core area shapefiles and resistance layers needed to run Circuitscape and LinkageMapper analyses. The Rmd files calls the three DataProcessing R scripts to create the land use layers (Landuse.R), create the resistance layer from these (Resistance.R), and then create the core areas (CoreAreas.R) These spatial outputs were then referenced directly in Connectivity analyses in ArcGIS for running Circuitscape and Linkage Mapper Analyses.

### 2\_Analysis.Rmd

This document analyzes the results of the Circuitscape and Linkage Mapper Runs. Visualizations of the results were created in ArcGIS within the project..

The GIS file where the runs were completed is Data/2\_Analysis/Circuitscape/KitFox\_RunAnalyses.mxd folder. KitFoxCoreAreas.mxd was used in the creation of Western Kern core areas. KitFox\_CompareOutputs.mxd is just a quick check of different analysis outputs. Paper\_Maps has the visualizations of results with the mxd used to make the pngs and some of the calculations that were completed to create the maps.

##Circuitscape

The ArcGIS Circuitscape toolbox (Circuitscape\_for\_ArcGIS\_2013\_10\_08\_rev2) was used to run the analyses. For Circuitscape, an ASCII file of the Kit Fox core area shapefile data was created using the focal area to raster tool in the Circuitscape toolbox (works better than creating ASCII in R). These are saved in the Data/1\_DataProcessing/CoreArea folder for each year (ASCII created using each separate year resistance ASCII layer). Circuitscape was run for each resistance layer with each matching core area ASCII file. Ran pairwise analysis for cumulative current, and other settings standard.

Toolbox and results from the run saved in folder above the R project, and run on local drive where possible, for better processing.

##Linkage Mapper

The ArcGIS Linkage Mapper toolbox (Linkage\_Mapper\_2\_0\_0) was used to run the linkage mapper analyses. For Linkage Mapper, the resistance rasters and the kit fox core area shapefiles were used. For settings, dropped corridors that intersect core areas and truncated corridors at 200 km.

Toolbox and results from the run saved in folder above the R project, and run on local drive where possible, for better processing.

##Pinchpoint Mapper

For Pinchpoint Mapper, ran on linkage mapper output with same core areas shapefile and resistance ASC used. For settings, used CWD cutoff distance of 200 km, and calculated adjacent pair pinch points using Circuitscape.

## Data

### 1\_DataProcessing

#### CoreAreas

Contains the core areas created by the CoreArea.R script as well as the final versions used for each year as described above (For Circuitscape, an ASCII file of the Kit Fox core area shapefile data was created using the focal area to raster tool in the Circuitscape toolbox (works better than creating ASCII in R). These are saved in the Data/1\_DataProcessing/CoreArea folder for each year (ASCII created using each separate year resistance ASCII layer)).

#### CWHR

All processing for the Kit Fox California Wildlife Habitat Relationships habitat suitability files. Kit Fox Shapefile created from downloaded CWHR Habitat Raster: <https://map.dfg.ca.gov/metadata/ds2599.html>. Kit Fox geodatabase file (ds2599 folder unzipped) made into TIF file using Lookup tool (for Mean\_100 value column) (ds2599.tif). Then aggregated at 270 meters using median value, then raster to polygon (ds\_2599\_agg270median tif and shp). Then ran through the CoreArea.R code that aggregates polygon with 270m buffer using only Mean\_100=92 values (highest/best core area values), and that also finds only those polygons with area greater than 5 ha. All of the files can be seen in the mxd file within the folder.

More detailed:

We defined critical habitat of the Kit Fox using the California Wildlife Habitat Relationships (CWHR) Predicted Habitat Suitability raster for the Kit Fox, downloaded as a geodatabase file from the California Department of Fish and Wildlife BIOS (<https://wildlife.ca.gov/data/cwhr>; <https://map.dfg.ca.gov/metadata/ds2599.html>; https://apps.wildlife.ca.gov/bios/?al=ds2599 ). The 30 m resolution raster depicts the area of predicted habitat suitability within the Kit Fox species range based on a combination of the California Wildlife Habitat Relationships (CWHR 2016) data and statewide vegetation map (FVEG2015, FRAP 2015).

In ArcGIS, we transformed the gdb file into a TIF using the Lookup tool on the Mean\_100 column, which gives the mean habitat suitability score for the species as an integer from 0 to 100.  These values are defined by the average of expert defined reproduction, cover, and feeding scores for the species in the habitat type (<https://map.dfg.ca.gov/metadata/ds2599.html>). A value of 1 is determined high suitability for these individual layers, while 0.66 is medium. For the layers averaged together for the mean suitability score, values >66 are defined as high suitability for the species. We then aggregated the raster at 270 meters for ease of processing using the median value, and wrote to polygons.

In R, these polygons were then subset for the highest value core areas, defined as values equal to 92, as it was the highest value in the mean suitability score column (no 1 values). This only selected those areas that have the highest suitability scores across all three metrics, and limited core areas to more realistic and manageable portions of the landscape.

These polygons were cropped to Kern county, and then aggregated together within a 270 m buffer to join connecting polygons. Each remaining unique core area was given a unique identifier. There were many tiny and isolated suitable habitat polygons that were far too small to be suitable home ranges or habitat areas for the Kit Fox and that would complicate and slow down processing. The home range size of the Kit Fox varies from about 2.4 to 11.6 km2 (240 to 1160 ha), and is typically about 3.22 km2 (322 ha) in size, holding up to 3 individuals (Koopman et al 200; List and Cypher 2005; McCue and O’Farrell 1992?). Therefore, we calculated the area of each polygon in hectares and removed polygons with areas less than 5 hectares, as this was far below the home range size while still removing many of the tiny polygons (0.05 km2). The end result was 174 unique Core habitat polygons (51 small polygons removed). We saved the shapefile for spatial connectivity analyses.

#### DEM

Downloaded and processed elevation and slope data.

We also calculated elevation and slope values to include in our resistance layer. Elevation data was retrieved from the USDA National Elevation Dataset (NED) as 30 m resolution raster files (<https://viewer.nationalmap.gov/advanced-viewer/>). We used the USDA viewer to select and download all DEM layers around Kern county, and downloaded according to the viewer instructions (<https://viewer.nationalmap.gov/uget-instructions/index.html>). In R, we combined all the separate DEM files into one combined raster layer, and then reprojected the layer to the projection of analysis and cropped and masked it to Kern county. We used the terrain function to calculate slope in radians from the DEM layer. We resampled the slope layer to ensure the same extent, origin, and coordinate system as the Kern county raster layer and calculated the proportion slope by taking the tangent of radians slope.

#### KernCounty

Kern county served as the extent of analysis, and was defined by rasterizing the TIGER 2019 county border at 30 meter resolution (TIGER 2019). This is the Kern County shapefile.

#### Landuse

Land cover was defined from three land use datasets: USGS Fallowing Area Mapping (FAM), Land IQ LLC and California Department of Water Resources (DWR) California Crop Mapping (LandIQ), and USGS National Land Cover Database (NLCD).

The FAM land use layers, illustrating fallowed area coverage across California for each year between 2011 and 2017, were provided by the creators of the dataset at USGS as raster TIF layers (Forrest, etc.). We used the annual fallow data layers to define annual fallowed areas with a value of 1 and set all other land cover to NA. We projected the 30 m resolution layers to the same extent and projection as our Kern county layer using nearest neighbor methods.

The LandIQ crop cover layers were available for 2014 and 2016, and were downloaded from the California natural resources agency DWR statewide crop mapping site as shapefiles (https://data.cnra.ca.gov/dataset/statewide-crop-mapping). The layers identify crop types and other land uses within the crop intensive areas of California using remote sensing. We used the Crop2014 and Crop2016 columns of the shapefile to define the land cover and gave unique code for each unique crop type so the layer could be joined with the other land use layers (table in crop folder). We rasterized the layers by this unique crop ID using the extent, projection, and 30 m resolution of our Kern county layer with the fasterize tool.

The NLCD land use layers for 2011 and 2016 were downloaded as raster TIFs from the Multi-Resolution Land Characteristics (MLRC) consortium as part of the NLCD Land Cover (CONUS) All Years download (https://www.mrlc.gov/data). We clipped the 2011 and 2016 NLCD layers to California in ArcGIS for ease of processing, before clipping and resampling the 30 m resolution layers to Kern county in R using nearest neighbor methods.

We then combined these three separate land use layers into one consolidated land use map for Kern county. As we wanted to see how the change in fallow area (FAM cover) influenced the change in species connectivity across the years and as that was the dataset we had available for every year of analysis, we allowed the FAM input to change each year while holding the LandIQ and the NLCD static. Therefore, we combined every year of the FAM dataset from 2011 to 2017 with the 2016 Land IQ dataset and the 2016 NLCD. We later examined the impact of these static layers by comparing the connectivity results from the 2011 FAM combined with the 2016 LandIQ and 2016 NLCD to the results from the 2011 FAM combined with the 2014 LandIQ and 2011 NLCD. To combine the layers together we used the cover function, giving precedence to FAM, then LandIQ, and then NLCD. Essentially, the FAM layer NA values were filled in with values from the LandIQ crop cover values, and then any remaining NA values were filled in with the NLCD land cover values.

#### Resistance

The land cover values were then reclassified as Kit Fox resistance values. Kit Fox resistance values to certain land cover types were derived from a paper detailing Kit Fox Habitat Suitability (<https://www.canids.org/CBC/16/san_joaquin_kit_fox_habitat_suitability.pdf>). We created a linkage table connecting these habitat suitability values (0 to 100) to our final land cover types in the consolidated land use map for Kern County (within KitFox folder, ResistanceValues.csv). Habitat suitability values were converted to 0 to 1 values, and then inverted to represent resistance instead of suitability. A value of 1 was deemed highest resistance, and 0 has lowest resistance. We used this resistance reclassification table to reclassify the land use layer and output resistance raster for Kern county for each year of analysis. (KitFox folder ResistanceValues tifs for each year): Fallow (FAM) and idle (LandIQ) land cover were defined as separate entities to show the impact of changing FAM fallow values and as the FAM layer had precedence. We also ran a version that combined these two land cover classes into one fallow cover class and ran the connectivity analyses which did not significantly impact the results (did not copy over this file but can if needed). The csv for this is available as \_CombFI.csv.

To create final resistance layers that combine land cover resistance, barrier resistance, and slope, we calculated the resistance surface using the equation #5 as detailed in Dickson et al. 2017. The equation is : resistance <-((max\_resistance+1)^10) + (slope/4)]. Therefore, we calculated the maximum resistance value across our resistance layers (land use, roads, rivers), removing NA values in the calculation, which are saved in this folder as max\_year tif files. We then input this max resistance layer and the proportion slope layer into the resistance formula to create our final resistance surface. The 30 m resistance surface layers (for each year) were then aggregated to 270 meter resolution for faster processing using the aggregate function with a factor of 9. We set all NA values as -9999 and wrote the output as ASCII files, both of which are required for Circuitscape. These asc files are available in this folder as resistance\_year.asc.

#### Rivers

Rivers data was retrieved from the USGS National Hydrologic Dataset for CA using the NHDArea shapefile (<https://www.usgs.gov/core-science-systems/ngp/national-hydrography/access-national-hydrography-products>). We rasterized the river polygons to the Kern county raster using fasterize, which had river presence given a value of 1 for highest resistance possible, and background values set as 0 resistance.

#### Roads

Roads data for Kern County was taken from the TIGER 2019 Primary and Secondary Roads dataset for California, which has roads as linestring shapefiles (<https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2019&layergroup=Roads>).   
We rasterized the linestrings to the Kern county raster using rasterize (fasterize does not work on linestrings), setting a field value of 1 to establish road presence and a resistance value of 1 (highest possible resistance), and setting all other background values to 0.

#### TIGER2019Counties

The TIGER 2019 county border at 30 meter resolution for the US, used to subset Kern County and create Kern County border shapefile above.

### 2\_Analysis

#### Circuitscape

Run and examine circuitscape results. Mostly mxd and png files.

The GIS file where the runs were completed is Data/2\_Analysis/Circuitscape/KitFox\_RunAnalyses.mxd folder. KitFoxCoreAreas.mxd was used in the creation of Western Kern core areas. KitFox\_CompareOutputs.mxd is just a quick check of different analysis outputs. Paper\_Maps has the visualizations of results with the mxd used to make the pngs and some of the calculations that were completed to create the maps.

#### LCP\_CSV

Csv dataframes for the least cost path results for 2011, 2015, and 2017. Just for ease of sending to Larsen and Powers.

#### Stats

Least Cost Path statistical results, specifically the various t-tests run examining least cost path results between years.

## R

Only R scripts for 1\_DataProcessing; No R scripts for 2\_Analysis—all performed in Rmd.

### 1\_DataProcessing

#### CoreAreas.R

Created Highest Core Areas for the San Joaquin Kit Fox in Kern County. Repeating information from above below:

We defined critical habitat of the Kit Fox using the California Wildlife Habitat Relationships (CWHR) Predicted Habitat Suitability raster for the Kit Fox, downloaded as a geodatabase file from the California Department of Fish and Wildlife BIOS (<https://wildlife.ca.gov/data/cwhr>; <https://map.dfg.ca.gov/metadata/ds2599.html>; https://apps.wildlife.ca.gov/bios/?al=ds2599 ). The 30 m resolution raster depicts the area of predicted habitat suitability within the Kit Fox species range based on a combination of the California Wildlife Habitat Relationships (CWHR 2016) data and statewide vegetation map (FVEG2015, FRAP 2015).

In ArcGIS, we transformed the gdb file into a TIF using the Lookup tool on the Mean\_100 column, which gives the mean habitat suitability score for the species as an integer from 0 to 100.  These values are defined by the average of expert defined reproduction, cover, and feeding scores for the species in the habitat type (<https://map.dfg.ca.gov/metadata/ds2599.html>). A value of 1 is determined high suitability for these individual layers, while 0.66 is medium. For the layers averaged together for the mean suitability score, values >66 are defined as high suitability for the species. We then aggregated the raster at 270 meters for ease of processing using the median value, and wrote to polygons.

In R, these polygons were then subset for the highest value core areas, defined as values equal to 92, as it was the highest value in the mean suitability score column (no 1 values). This only selected those areas that have the highest suitability scores across all three metrics, and limited core areas to more realistic and manageable portions of the landscape.

These polygons were cropped to Kern county, and then aggregated together within a 270 m buffer to join connecting polygons. Each remaining unique core area was given a unique identifier. There were many tiny and isolated suitable habitat polygons that were far too small to be suitable home ranges or habitat areas for the Kit Fox and that would complicate and slow down processing. The home range size of the Kit Fox varies from about 2.4 to 11.6 km2 (240 to 1160 ha), and is typically about 3.22 km2 (322 ha) in size, holding up to 3 individuals (Koopman et al 200; List and Cypher 2005; McCue and O’Farrell 1992?). Therefore, we calculated the area of each polygon in hectares and removed polygons with areas less than 5 hectares, as this was far below the home range size while still removing many of the tiny polygons (0.05 km2). The end result was 174 unique Core habitat polygons (51 small polygons removed). We saved the shapefile for spatial connectivity analyses.

#### Landuse.R

Repeating information from above about how landuse files were created:

Land cover was defined from three land use datasets: USGS Fallowing Area Mapping (FAM), Land IQ LLC and California Department of Water Resources (DWR) California Crop Mapping (LandIQ), and USGS National Land Cover Database (NLCD).

The FAM land use layers, illustrating fallowed area coverage across California for each year between 2011 and 2017, were provided by the creators of the dataset at USGS as raster TIF layers (Forrest, etc.). We used the annual fallow data layers to define annual fallowed areas with a value of 1 and set all other land cover to NA. We projected the 30 m resolution layers to the same extent and projection as our Kern county layer using nearest neighbor methods.

The LandIQ crop cover layers were available for 2014 and 2016, and were downloaded from the California natural resources agency DWR statewide crop mapping site as shapefiles (https://data.cnra.ca.gov/dataset/statewide-crop-mapping). The layers identify crop types and other land uses within the crop intensive areas of California using remote sensing. We used the Crop2014 and Crop2016 columns of the shapefile to define the land cover and gave unique code for each unique crop type so the layer could be joined with the other land use layers (table in crop folder). We rasterized the layers by this unique crop ID using the extent, projection, and 30 m resolution of our Kern county layer with the fasterize tool.

The NLCD land use layers for 2011 and 2016 were downloaded as raster TIFs from the Multi-Resolution Land Characteristics (MLRC) consortium as part of the NLCD Land Cover (CONUS) All Years download (https://www.mrlc.gov/data). We clipped the 2011 and 2016 NLCD layers to California in ArcGIS for ease of processing, before clipping and resampling the 30 m resolution layers to Kern county in R using nearest neighbor methods.

We then combined these three separate land use layers into one consolidated land use map for Kern county. As we wanted to see how the change in fallow area (FAM cover) influenced the change in species connectivity across the years and as that was the dataset we had available for every year of analysis, we allowed the FAM input to change each year while holding the LandIQ and the NLCD static. Therefore, we combined every year of the FAM dataset from 2011 to 2017 with the 2016 Land IQ dataset and the 2016 NLCD. We later examined the impact of these static layers by comparing the connectivity results from the 2011 FAM combined with the 2016 LandIQ and 2016 NLCD to the results from the 2011 FAM combined with the 2014 LandIQ and 2011 NLCD. To combine the layers together we used the cover function, giving precedence to FAM, then LandIQ, and then NLCD. Essentially, the FAM layer NA values were filled in with values from the LandIQ crop cover values, and then any remaining NA values were filled in with the NLCD land cover values.

#### Resistance.R

Repeating information from above about how final resistance layers were created:

The land cover values were then reclassified as Kit Fox resistance values. Kit Fox resistance values to certain land cover types were derived from a paper detailing Kit Fox Habitat Suitability (<https://www.canids.org/CBC/16/san_joaquin_kit_fox_habitat_suitability.pdf>). We created a linkage table connecting these habitat suitability values (0 to 100) to our final land cover types in the consolidated land use map for Kern County (within KitFox folder, ResistanceValues.csv). Habitat suitability values were converted to 0 to 1 values, and then inverted to represent resistance instead of suitability. A value of 1 was deemed highest resistance, and 0 has lowest resistance. We used this resistance reclassification table to reclassify the land use layer and output resistance raster for Kern county for each year of analysis. (KitFox folder ResistanceValues tifs for each year): Fallow (FAM) and idle (LandIQ) land cover were defined as separate entities to show the impact of changing FAM fallow values and as the FAM layer had precedence. We also ran a version that combined these two land cover classes into one fallow cover class and ran the connectivity analyses which did not significantly impact the results (did not copy over this file but can if needed). The csv for this is available as \_CombFI.csv.

To create final resistance layers that combine land cover resistance, barrier resistance, and slope, we calculated the resistance surface using the equation #5 as detailed in Dickson et al. 2017. The equation is : resistance <-((max\_resistance+1)^10) + (slope/4)]. Therefore, we calculated the maximum resistance value across our resistance layers (land use, roads, rivers), removing NA values in the calculation, which are saved in this folder as max\_year tif files. We then input this max resistance layer and the proportion slope layer into the resistance formula to create our final resistance surface. The 30 m resistance surface layers (for each year) were then aggregated to 270 meter resolution for faster processing using the aggregate function with a factor of 9. We set all NA values as -9999 and wrote the output as ASCII files, both of which are required for Circuitscape. These asc files are available in this folder as resistance\_year.asc.

# ConnectivityTools

## Circuitscape for ArcGIS 2013

For Circuitscape analyses, we used Circuitscape 4.0 through the ArcGIS Toolbox aka Circuitscape for ArcGIS 2013 software.

Circuitscape relies on circuit theory to model species movement through the landscape as a function of current flow through the landscape (McRae et al. 2008; McRae and Shah 2009). The tool requires ASCII file inputs of the resistance layer of the species of analysis as well as the core areas or nodes to examine current flow between.  For Circuitscape, an ASCII file of the Kit Fox core area shapefile data was created using the focal area to raster tool in the Circuitscape toolbox. This ASCII file along with the resistance ASCII layer we inputted into Circuitscape for each year of analysis, and ran for pairwise analysis between core area nodes to calculate the cumulative current in the landscape.

## Linkage Mapper 2\_0\_0

For Linkage Mapper we used the Linkage Mapper 2.0 through the ArcGIS Toolbox (McRae and Kavanagh 2011).

From the Linkage Mapper Toolbox we used the Linkage Pathways and Pinchpoint Mapper tools to further examine spatial connectivity.

Linkage Pathways calculates the least-cost pathways for species movement by calculating the cost-weight distanced accrued, or the total resistance to movement, while traversing across the resistance surface between core areas (instruction guide). The output is a corridor map of all least-cost pathways between all identified neighboring core areas (instruction guide). More detailed methodology on the tool can be found in Chapter 2 and Appendix D of the 2010 Washington Wildlife Habitat Connectivity Working Group (WHCWG) paper, which developed this tool to complete statewide wildlife connectivity assessments (cite). The ASCII resistance surface along with the core area shapefiles were put into the Linkage Pathways tool to calculate the least cost path corridors for Kit Fox movement for each year of analysis. We dropped corridors that intersected core areas, as we were interested in change in movement between and not through core areas, and truncated corridors at 200 km. Along with the output corridor maps is a table of calculated values for each pathway, including total pathway length and accumulated cost-weighted distance.

Pinchpoint Mapper was created as part of the Linkage Mapper Toolkit, and uses the outputs of the Linkage Pathways tools as input for running Circuitscape current flow analyses within these pathways (McRae 2012). The tool outputs current maps within the least-cost corridors that illustrate potential bottlenecks to species movements, or pinch points (pinch point instruction guide). The tool also updates the linkage pathways table to include information on the effective resistance values for each corridor (pinch point instruction guide). We ran the Pinchpoint tool on our linkage mapper outputs with the same core area shapefiles and resistance ASCII files used to create those files, set the CWD cutoff distance at 200 km to match our truncated corridors, and set calculations to adjacent pair pinch points.

## Results

See Circuitscape and Linkage Mapper software sections directly above to see how processes were run. This folder contains the results from these analyses, which were run on the C drive for optimal processing and then moved here. For the folders below, all Linkage Mapper results (LCP with pinchpoint analysis) can be found in the KF\_2011 and so on folders. Circuitscape analyses can be found in the KF\_2011\_Circuit folders and so on. The KF\_2011compare folder has the results from changed land use to be dynamic for 2011 instead of static across, to compare results to KF\_2011. Essentially used 2011 FAM/2014 LandI/2011 NLCd vs 2011 FAM/2016 LandIQ/2016 NLCD. KF\_2011\_AllCorridors was run to see difference in results where all corridors kept, instead of removing those that cross through core areas.

These results were directly called in 2\_Analysis.Rmd for performing statistical analyses.

#### KF\_2011

#### KF\_2011\_AllCorridors

#### KF\_2011\_Circuit

#### KF\_2011compare

#### KF\_2012

#### KF\_2012\_Circuit

#### KF\_2013

#### KF\_2013\_Circuit

#### KF\_2014

#### KF\_2014\_Circuit

#### KF\_2015

#### KF\_2015\_Circuit

#### KF\_2016

#### KF\_2016\_Circuit

#### KF\_2017

#### KF\_2017\_Circuit