Song meters do target bellows from male koalas, but the DPI research was designed as a regional, occupancy-based survey where many sites are surveyed (171 sites in this case). These surveys follow a standard approach in ecology where occupancy is assumed to be related to meta-population dynamics when a large number of sites are surveyed.

Mckenzie et al. (2003) state:

"Estimating the proportion of sites occupied by a target species is important in both long-term monitoring programs and metapopulation studies. In a monitoring context, site occupancy probabilities may be used as a metric reflecting the current state of the population."

In our case, on average 64 % of sites were occupied (more at low elevation and less at high elevation), indicating the presence of a widespread population. Forest harvesting treatment and land tenure (National Park Vs State forest) had no effect on occupancy.

As stated in Law et al. (2018):

"This is consistent with the view that such populations have been poorly detected in less accessible parts of NSW and that koalas may be more resilient than suspected in those areas [69]."

"Occupancy is an appropriate surrogate for population assessment when density is low as is expected for koalas [32, 35]. For example, given SM2/SM4s sample a 150–300 m radius of forest for koalas [38, 39], and male koala density in better quality forests of north-east NSW is 0.03 per ha [32], then just a single male would be expected in the acoustic sample area where a bellow was recorded… Bellowing also serves both to avoid male-male interactions by functioning as a signal of body size [48, 49] and to attract females [29], and thus an increase in bellow rate likely reflects an increase in breeding activity in a population [29, 50]."

Such survey approaches have been used for many years in frog surveys where the male represents the calling portion of the population (female frogs do not call). In the case of koalas, populations are considered to have a 1:1 sex ratio and so it is reasonable to assume the presence of bellowing males (i.e. reproductively active males) would also indicate the presence of local females.

Other koala survey methods such as scat collection typically do not reveal the sex of the animal unless very fresh scats are collected and they are subjected to DNA analysis. The same is true of camera trap surveys – often the sex of the animal can't be determined.

Law et al. (2018) took these acoustic data a step further to relate bellow rate (bellows per night) to the different forest treatments sampled. Bellow rate has recently been shown to be correlated with koala density (Hagans et al. 2018), so this index provides a more direct measure of koala populations at a site. The highest bellow rate (23 calls per night) across all sites surveyed was recorded at one site in Kiwarrak State Forest that was recently heavily harvested (though with a mosaic of harvest exclusions). This was a greater call rate than what was recorded at other well-known koala populations sampled in the study, such as Royal Camp State Forest and Bongil Bongil National Park. Overall, forest treatment had no statistically significant effect on bellow rate.

All surveys have their limitations, so the acoustic method used does not provide direct information on breeding success, except via assessment of meta-population occupancy. DPI has now collected acoustic data from ~ 60 sites per year over the past four years, providing a strong base-line for koala monitoring. Ongoing monitoring would provide a powerful means of assessing change in koala meta-populations in the hinterland forests of north-east NSW.

Given survey limitations, more detailed data on habitat use by male and female koalas in forestry landscapes is currently being collected using GPS technology. This site-based research will be complimentary to the landscape survey outlined in Law et al. (2018) in that it will provide data on the parts of the landscape that individual koalas use.

Can you please provide a GIS shapefile (or excel spreadsheet if a shapefile is not available) with the precise geographic locations of the 171 song meter sites, including information on what logging treatment they were assigned to?

See attached file.

year of sampling	harvest_treatment	zone	x_proj	y_proj	datum
2016	Light-Medium,<11	56	447550.4218	6421435.211	WGS84
2016	Old Growth	56	360604.4719	6441886.319	WGS84
2017	Heavy,>24	56	453286.8991	6492903.082	WGS84
2017	Heavy,<11	56	454526.7068	6497522.025	WGS84
2017	Light-Medium,>24	56	479972.8889	6528767.844	WGS84
2017	Heavy,<11	56	481593.0109	6551661.738	WGS84
2017	Heavy,<11	56	475020.4112	6554834.666	WGS84
2017	Old Growth	56	474240.9991	6547349.818	WGS84
2017	Light-Medium,11-24	56	471662.585	6548206.785	WGS84
2017	Old Growth	56	463175.8206	6549921.919	WGS84
2017	Old Growth	56	460335.2837	6554869.3	WGS84
2017	Light-Medium,>24	56	458170.445	6555350.709	WGS84
2015	Light-Medium,>24	56	485326.8102	6592505.258	WGS84
2015	Light-Medium,<11	56	499272.0324	6611738.164	WGS84
2015	Heavy,<11	56	491229.9114	6585010.818	WGS84
2015	Heavy,>24	56	499341.1804	6621909.372	WGS84
2015	Heavy,11-24	56	486475.3902	6592480.949	WGS84
2016	Light-Medium,>24	56	357498.5232	6443704.486	WGS84
2017	Old Growth	56	461549.13	6557379.435	WGS84
2017	Heavy,<11	56	493281.4288	6594601.861	WGS84
2017	Heavy,<11	56	490742.7199	6591556.581	WGS84
2017	Old Growth	56	422138.2475	6725706.372	WGS84
2017	Light-Medium,>24	56	424652.3794	6731672.634	WGS84
2017	Light-Medium,>24	56	414661.1174	6720941.762	WGS84
2017	Old Growth	56	364359.7851	6643726.513	WGS84
2017	Light-Medium,11-24	56	427370.3399	6621552.418	WGS84
2017	Light-Medium,>24	56	419296.3557	6618241.793	WGS84
2017	Heavy,>24	56	424776.1347	6614248.068	WGS84
2016	Light-Medium,11-24	56	382361.547	6432687.503	WGS84
2017	Heavy,>24	56	419859.395	6609470.782	WGS84
2017	Heavy,>24	56	414158.7927	6602101.001	WGS84
2017	Light-Medium,>24	56	415613.4523	6604894.549	WGS84
2017	Light-Medium,<11	56	343898.7328	6515533.857	WGS84
2017	Heavy,<11	56	339481.8606	6518491.587	WGS84
2017	Heavy,>24	56	402202.3337	6534836.942	WGS84
2017	Light-Medium,<11	56	397047.3965	6534305.295	WGS84
2017	Heavy,<11	56	399628.8362	6525870.791	WGS84
2017	Light-Medium,11-24	56	393102.0904	6532761.885	WGS84
2017	Heavy,<11	56	383185.1572	6532552.167	WGS84
2015	Light-Medium,>24	56	443858.7139	6772263.476	WGS84
2015	Light-Medium,11-24	56	446751.6357	6770847.233	WGS84
2016	Light-Medium,<11	56	382513.887	6431992.879	WGS84
2017	Light-Medium,<11	56	377498.9473	6530594.098	WGS84
2017	Old Growth	56	382785.2698	6512865.714	WGS84
2017	Light-Medium,11-24	56	384504.4282	6507834.4	WGS84
2017	Light-Medium,<11	56	378570.9229	6506701.127	WGS84
2017	Light-Medium,<11	56	390304.4808	6492574.383	WGS84
2015	Light-Medium,11-24	56	489320.5372	6790692.116	WGS84
2015	Light-Medium,<11	56	461277.6782	6781329.894	WGS84
2016	Light-Medium,<11	56	377006.3574	6442192.311	WGS84
2015	Light-Medium,11-24	56	474778.3485	6829826.771	WGS84
2015	Light-Medium,<11	56	471722.7508	6828094.921	WGS84

2015 Light-Medium,11-24	56	475997.1714	6821918.786	WGS84
2016 Old Growth	56	380594.2709	6432391.169	WGS84
2015 Light-Medium,>24	56	459322.2479	6844847.939	WGS84
2015 Light-Medium,11-24	56	456944.656	6844209.858	WGS84
2016 Heavy,<11	56	427532.5295	6418886.557	WGS84
2015 Light-Medium,11-24	56	500000.4868	6786226.506	WGS84
2015 Heavy,11-24	56	500028.984	6775713.573	WGS84
2016 Light-Medium,<11	56	427531.3072	6422602.307	WGS84
2016 Koala High Use Area	56	425593.6644	6429605.634	WGS84
2016 Light-Medium,11-24	56	425408.5119	6433741.358	WGS84
2015 Light-Medium,11-24	56	397166.846	6387752.241	WGS84
2016 Old Growth	56	447809.3667	6423423.937	WGS84
2016 Heavy,<11	56	448641.383	6455939.804	WGS84
2016 Light-Medium,>24	56	447419.3419	6456408.674	WGS84
2016 Light-Medium,>24	56	444872.5814	6461731.133	WGS84
2016 Light-Medium,>24	56	445711.7801	6479390.334	WGS84
2016 Light-Medium,11-24	56	445821.5186	6481124.968	WGS84
2016 Heavy,<11	56	461452.6553	6483765.589	WGS84
2016 Light-Medium,<11	56	464961.0002	6483340.964	WGS84
2016 Old Growth	56	473217.4302	6486704.13	WGS84
2016 Heavy,<11	56	481008.3485	6508520.874	WGS84
2016 Light-Medium,>24	56	478774.5442	6506801.589	WGS84
2015 Heavy,<11	56	467807.8619	6507359.486	WGS84
2015 Old Growth	56	464122.5269	6504807.899	WGS84
2016 Heavy,11-24	56	448547.0573	6421868.576	WGS84
2016 Light-Medium,11-24	56	479051.6604	6506031.399	WGS84
2016 Koala High Use Area	56	475404.0089	6529153.775	WGS84
2016 Heavy,<11	56	473755.3795	6528877.898	WGS84
2016 Koala High Use Area	56	458040.8216	6536605.148	WGS84
2016 Heavy,<11	56	457000.9777	6539249.418	WGS84
2016 Light-Medium,<11	56	455048.5566	6541274.929	WGS84
2016 Heavy,>24	56	445511.2686	6546015.551	WGS84
2016 Light-Medium,>24	56	449956.7596	6543412.521	WGS84
2016 Koala High Use Area	56	465475.3102	6493154.939	WGS84
2016 Light-Medium,11-24	56	471909.5947	6493955.844	WGS84
2015 Light-Medium,11-24	56	400745.4308	6535533.686	WGS84
2015 Light-Medium,<11	56	403227.4568	6534422.9	WGS84
2016 Heavy,11-24	56	445593.3608	6424088.766	WGS84
2016 Light-Medium,11-24	56	418722.4517	6521722.701	WGS84
2016 Old Growth	56	418880.0893	6520968.74	WGS84
2016 Light-Medium,<11	56	425600.5326	6505701.675	WGS84
2016 Koala High Use Area	56	428288.8088	6498252.052	WGS84
2016 Heavy,<11	56	417392.2073	6498945.784	WGS84
2016 Heavy,>24	56	419161.7689	6495958.63	WGS84
2016 Old Growth	56	417514.3576	6496458.082	WGS84
2016 Heavy,>24	56	415900.046	6489714.246	WGS84
2016 Koala High Use Area	56	461599.0039	6538196.99	WGS84
2016 Heavy,<11	56	486993.9767	6578596.789	WGS84
2015 Light-Medium,11-24	56	379994.9392	6430756.001	WGS84
2015 Old Growth	56	376454.7912	6441800.547	WGS84
2015 Heavy,>24	56	380434.9194	6433037.456	WGS84
2016 Heavy,11-24	56	429353.7861	6428994.303	WGS84
2016 Old Growth	56	474868.0198	6587141.803	WGS84

2016 Old Growth	56	468537.8645	6605912.178	WGS84
2016 Light-Medium,>24	56	489717.5546	6620334.222	WGS84
2016 Heavy,<11	56	499924.6201	6619334.329	WGS84
2016 Koala High Use Area	56	504566.4328	6646752.332	WGS84
2016 Heavy,>24	56	494050.5073	6649763.347	WGS84
2016 Light-Medium,<11	56	498975.4507	6657259.488	WGS84
2016 Heavy,<11	56	496148.3349	6657890.375	WGS84
2016 Light-Medium,>24	56	492881.6812	6660934.616	WGS84
2016 Light-Medium,11-24	56	494991.0692	6660070.346	WGS84
2015 Light-Medium,>24	56	481347.9826	6540059.225	WGS84
2015 Light-Medium,<11	56	483746.4004	6554049.636	WGS84
2015 Light-Medium,>24	56	479729.4001	6540215.268	WGS84
2016 Koala High Use Area	56	425272.5457	6433498.354	WGS84
2016 Light-Medium,<11	56	488587.5249	6670130.718	WGS84
2016 Light-Medium,<11	56	487543.7878	6668993.782	WGS84
2016 Heavy,>24	56	480101.5423	6653422.748	WGS84
2016 Light-Medium,11-24	56	478602.3748	6659582.324	WGS84
2016 Light-Medium,>24	56	474342.2774	6658365.104	WGS84
2016 Old Growth	56	468995.4093	6657320.719	WGS84
2016 Light-Medium,<11	56	464810.4245	6656289.364	WGS84
2016 Koala High Use Area	56	459419.8322	6661267.899	WGS84
2016 Heavy,<11	56	461131.7274	6664992.669	WGS84
2016 Koala High Use Area	56	461088.3904	6668039.986	WGS84
2015 Light-Medium,<11	56	506856.9648	6698091.515	WGS84
2015 Heavy,>24	56	513015.1073	6663397.749	WGS84
2016 Light-Medium,<11	56	419664.5772	6400424.759	WGS84
2016 Koala High Use Area	56	449445.4627	6673472.738	WGS84
2016 Light-Medium,<11	56	450835.2671	6673898.344	WGS84
2017 Koala High Use Area	56	500652.4912	6645941.227	WGS84
2017 Heavy,>24	56	508897.8959	6654439.966	WGS84
2017 Old Growth	56	508268.1797	6652021.312	WGS84
2017 Heavy,<11	56	514655.0588	6668959.603	WGS84
2017 Heavy,>24	56	515503.9168	6674160.194	WGS84
2017 Light-Medium,>24	56	535671.4605	6832779.932	WGS84
2017 Heavy,11-24	56	536423.0002	6836067.781	WGS84
2017 Light-Medium,>24	56	538356.7528	6835112.707	WGS84
2015 Heavy,>24	56	481921.3354	6655881.517	WGS84
2015 Light-Medium,<11	56	478869.348	6656363.629	WGS84
2016 Heavy,<11	56	420067.1094	6400894.943	WGS84
2017 Light-Medium,>24	56	535966.2066	6848477.81	WGS84
2017 Light-Medium,>24	56	536927.5474	6850690.868	WGS84
2017 Light-Medium,>24	56	519768.0608	6855728.527	WGS84
2017 Light-Medium,>24	56	518751.3624	6852383.548	WGS84
2017 Heavy,>24	56	515760.5705	6848489.138	WGS84
2017 Light-Medium,>24	56	513726.3334	6781207.802	WGS84
2017 Koala High Use Area	56	494747.6441	6786397.587	WGS84
2017 Koala High Use Area	56	487938.447	6789061.665	WGS84
2017 Light-Medium,11-24	56	494449.218	6766427.306	WGS84
2017 Light-Medium,<11	56	510763.4668	6756253.592	WGS84
2015 Light-Medium,>24	56	461424.5422	6663638.675	WGS84
2015 Old Growth	56	460960.5915	6664855.762	WGS84
2015 Light-Medium,<11	56	457674.8751	6661602.947	WGS84
2016 Light-Medium,11-24	56	421195.49	6399869.201	WGS84

2017 Old Growth	56	510613.2475	6754890.375	WGS84
2017 Light-Medium,>24	56	390715.5317	6422870.713	WGS84
2017 Heavy,>24	56	405986.8921	6440756.405	WGS84
2017 Old Growth	56	387752.7399	6459562.948	WGS84
2017 Old Growth	56	385946.6804	6469411.478	WGS84
2017 Light-Medium,11-24	56	384495.2223	6470371.731	WGS84
2017 Old Growth	56	415992.5405	6412629.257	WGS84
2017 Heavy,<11	56	438533.7387	6459770.964	WGS84
2017 Light-Medium,<11	56	457779.8321	6487584.759	WGS84
2017 Heavy,>24	56	455274.5581	6489791.143	WGS84
2015 Heavy,>24	56	500130.1735	6638074	WGS84
2015 Heavy,>24	56	499608.2154	6638496.973	WGS84
2015 Light-Medium,>24	56	499585.4771	6635164.215	WGS84